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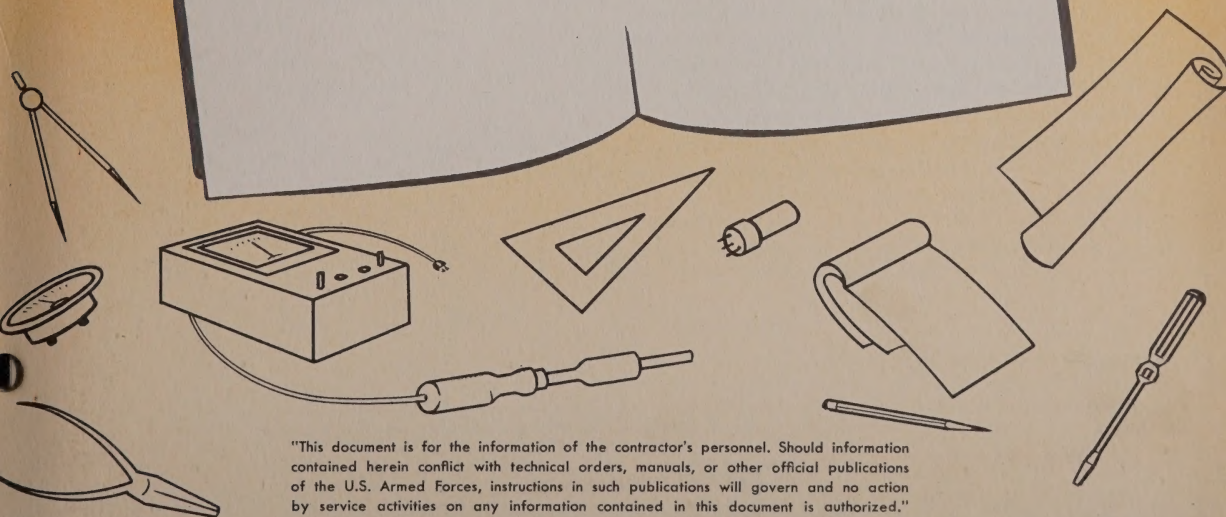
SERVICE

WORLD-WIDE WITH THE ARMED FORCES

PHILCO TRAINING MANUAL for

RADIO RECEIVER

BC-779-B



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LECTURE No. 1

INTRODUCTORY INFORMATION

Radio Receiver BC-779-B is a communications receiver, which is widely used in many types of communications systems. This receiver has good sensitivity, selectivity, and stability, and is provided with a balanced-input circuit, for use with a horizontal antenna and a balanced transmission line, to decrease the pick-up of local, man-made noise. The receiver covers the low-frequency and high-frequency bands most commonly used in communications systems, and it provides reception of both phone and c-w signals.

One use of this receiver is in a diversity reception system, for the reception of distant sky-wave signals. Such a system is especially useful in minimizing the effects of fading on teletypewriter operation. Figure 1 illustrates a method of obtaining polarization diversity reception by using a single horizontal half-wave doublet in conjunction with a balanced, center-tapped transformer. In this case, the horizontally polarized component is picked up by receiver R1, and the vertically polarized component by receiver R2. This provides constant reception of the transmitted signal regardless of its polarization, thus minimizing the fading effects.

Another important application of Radio Receiver BC-779-B is in an aircraft control system for routing airplanes from point to point, as shown in figure 2. An aircraft leaving point A will contact the air-to-ground station and will be given its flight plan. At the same time, the point-to-point station at A will contact the point-to-point station at B and notify them when to expect the aircraft. When the aircraft reaches a predetermined distance from B, it will contact the air-to-ground station located there and will receive further information. All of the receivers used in a system of this kind are usually BC-779-B's.

Another important use of the receiver is in an aircraft control tower at an airfield for establishing communications with aircraft leaving or entering the airfield. See figure 2.



LESSON PLAN No. 1

TIME ALLOTTED: ½ HR.

SUBJECT

Introductory information.

OBJECTIVE

To provide the student with an over-all picture of the equipment, including its function and application.

INTRODUCTION

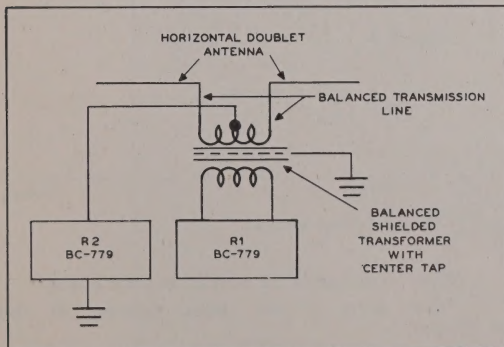
Radio Receiver BC-779-B is a flexible communications receiver which is designed for general use in most types of communications systems.

SUBJECT MATERIAL

1. The BC-779-B has very good sensitivity, selectivity, and stability.
2. Receiver has balanced-input to cut noise reception.
3. Receiver will work in radiophone or c-w systems.
4. Draw figure 1, and explain the use of the receiver in a diversity reception system.
5. Explain the function of the receiver in an aircraft control system.
6. Explain the use of the receiver in an aircraft control tower.

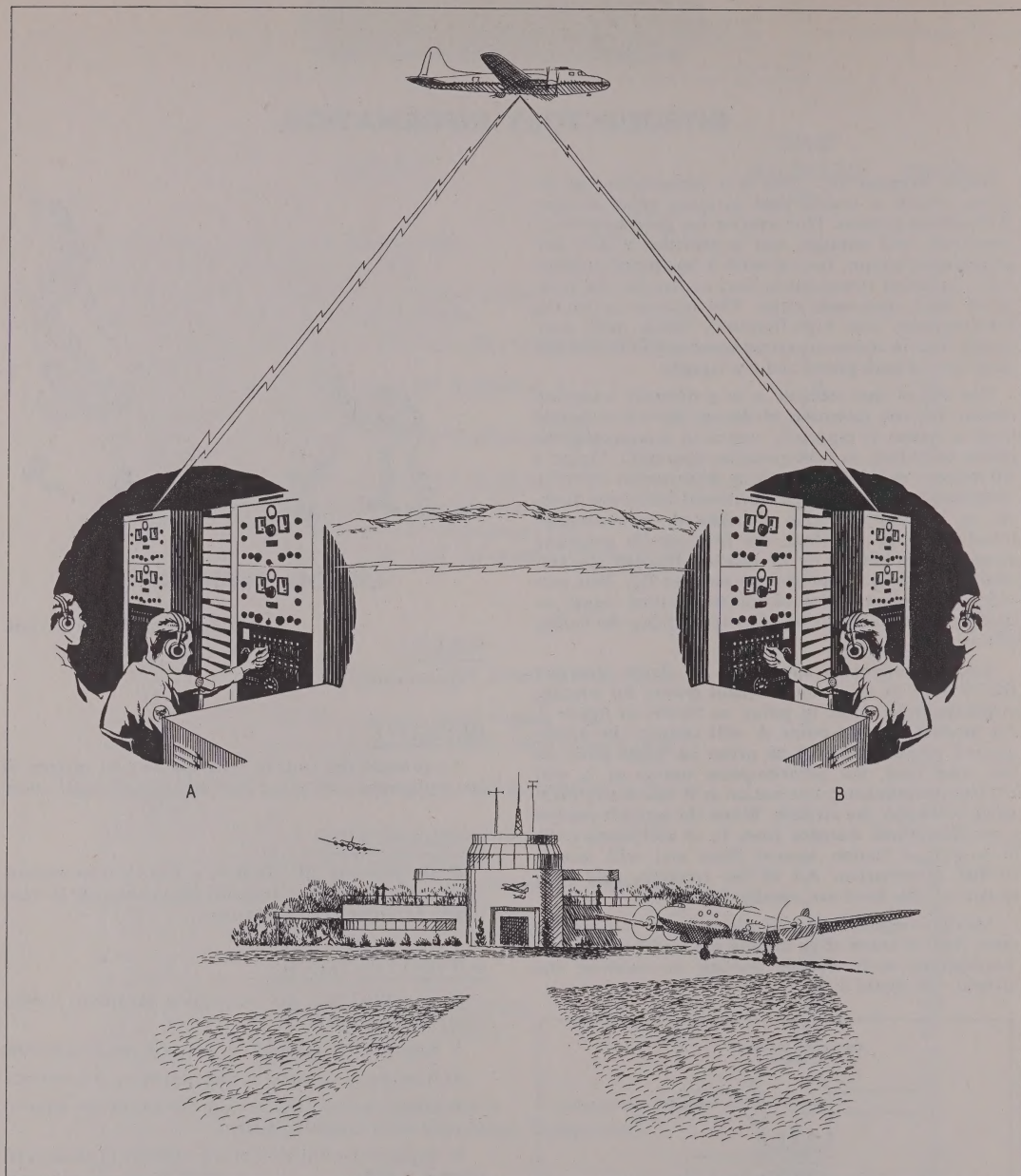
CONCLUSIONS

Radio Receiver BC-779-B has a wide variety of uses in communications systems. The design of the receiver makes it flexible and dependable in many important applications where a receiver of this type is necessary.



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Figure 1. Simplified Diversity Reception System



TP-9896

Figure 2. Use of Radio Receiver BC-779-B in Aircraft Control Systems

ORAL QUIZ

1. Why is Radio Receiver BC-779-B used extensively in communications systems?
2. What part does the receiver play in an aircraft control system?

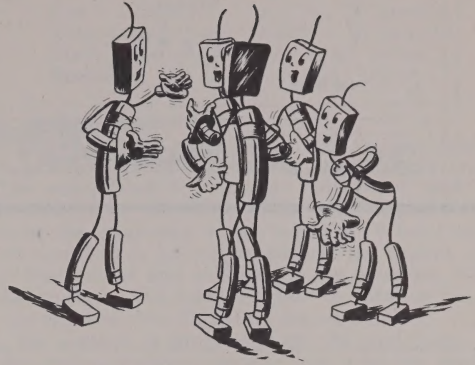
3. What is its use in an aircraft control tower?
4. Name some of the useful features of this equipment.
5. How is it used in diversity reception?

LECTURE No. 2

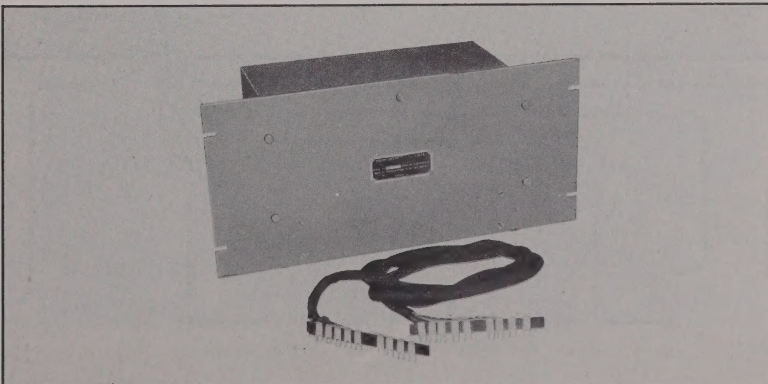
GENERAL DESCRIPTION

The equipment to be studied in this course consists of Radio Receiver BC-779-B and Power Supply Units RA-74-C, RA-84-B, and RA-94-A. Any one of these power-supply units can be used to operate the radio receiver. Figure 3 shows the radio receiver and a power-supply unit. All of the units are constructed to fit any standard 19" relay rack. The receiver is 10½" high, 19" wide, and 15⅝" deep and weighs 55 pounds. The power-supply units are each 10½" high, 19" wide, and 10" deep. RA-74-C weighs 61 pounds, and RA-84-B and RA-94-A weigh 57 pounds each. If it is desired to use the receiver as a table model, Cabinet CH-104-A can be used for the housing; this cabinet is 12¼" high, 23" wide, and 16½" deep.

The power requirements of the power-supply units



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TP-9093

Figure 3. Radio Receiver BC-779-B and Power Supply Unit RA-74-C, RA-84-B, or RA-94-A

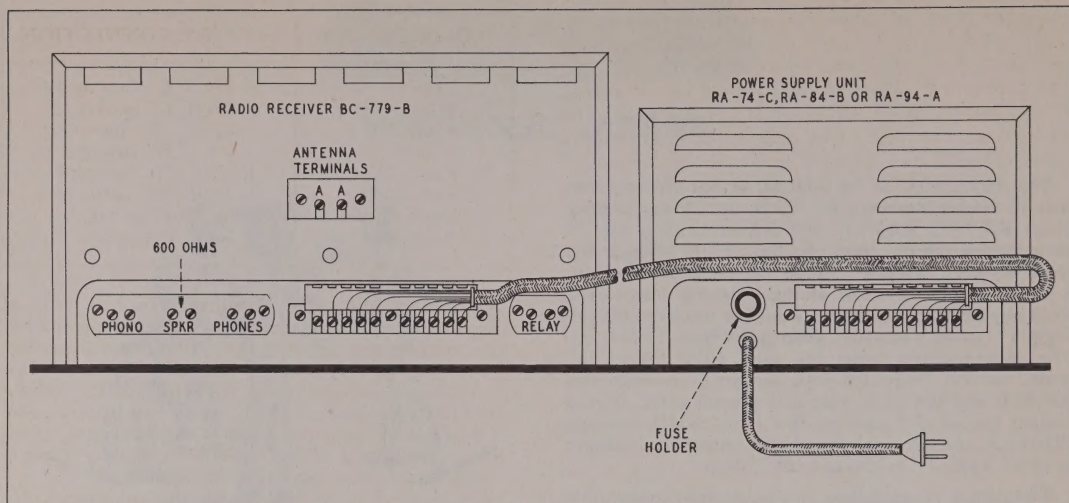


Figure 4. Interconnection of Radio Receiver and Power-Supply Unit

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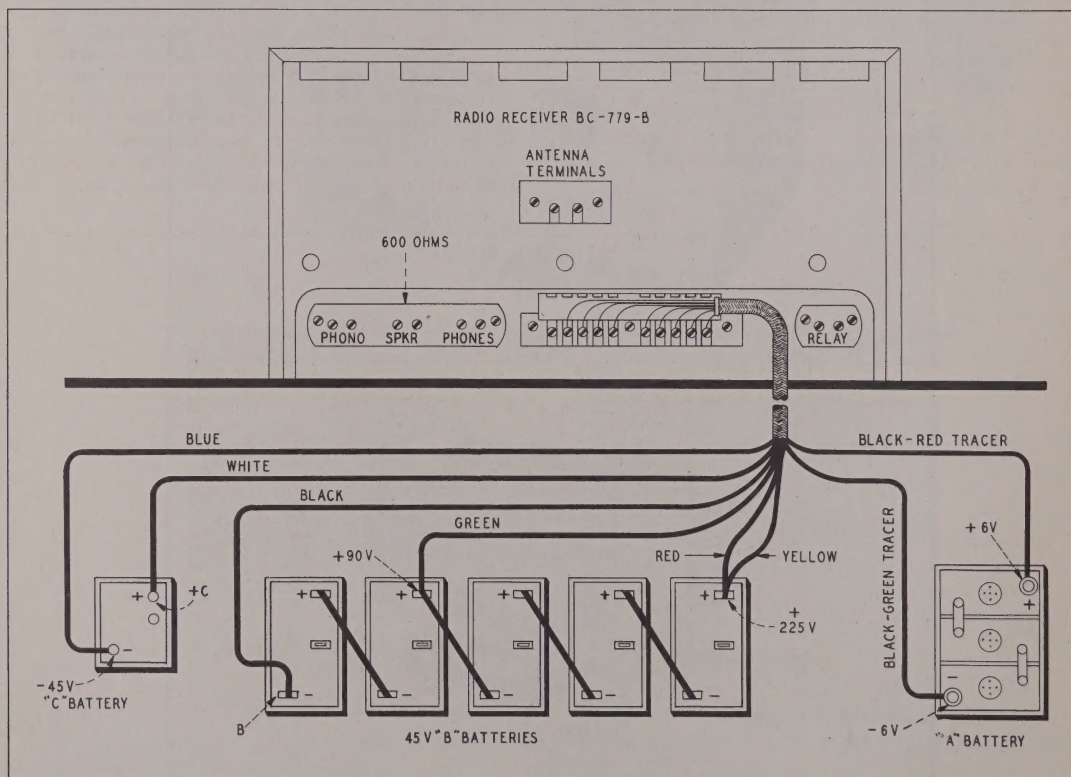


Figure 5. Interconnection of Radio Receiver and Battery Supply

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vary. The RA-84-B operates from a 50—60-cycle power source of 105, 115, or 125 volts; the RA-74-C operates from a 25—60-cycle power source of 95, 105, 117, 130, 190, 210, or 260 volts; and the RA-94-A operates from a 50—60-cycle power source of 115 or 230 volts. The average power consumed by each of the power-supply units is 180 watts. An input power cable and plug is provided at the rear of each power-supply unit and a fuse and fuse holder are located just above the plug.

A battery supply can be used as a source of power in place of the power-supply units. The batteries necessary are one 6-volt storage battery, five 45-volt "B" batteries connected in series to make a 225-volt supply, and one 45-volt "C" battery.

A connector cable is provided to connect the receiver to the power-supply unit chosen. To make the connection, the sheet metal cover for the terminal strips at the rear of each unit must be removed. The connector cable is constructed so that each of the eight leads is terminated in a spade lug at each end and the spade lugs are mounted on a terminal board. A glance at the cable will show that there is only one possible way of connecting the cable to the units. See figure 4.

If battery operation is necessary, another connector cable is available for the connection of the BC-779 to the battery supply. This cable has a set of eight leads. The leads at one end of the cable are terminated on a terminal strip in the same manner as the connector cable for the power-supply unit. The leads at the other end are loose and are terminated with spade lugs. The leads are all color-coded for proper connection to the batteries, as follows:

COLOR OF LEAD	BATTERY CONNECTION
Blue	—45v ("C" battery)
White	+45v ("C" battery)
Black	—225v ("B" battery)
Green	+90v ("B" battery)
Red	+225v ("B" battery)
Yellow	+225v ("B" battery)
Black-Green	—6v ("A" battery)
Black-Red	+6v ("A" battery)

The end of the cable terminated in the terminal strip connects to the receiver as described previously. The connections of the eight color-coded leads are determined by the color of the lead. Figure 5 illustrates the connection to the batteries. When making the installation, be sure to connect the battery cable to the receiver first and then to the batteries. When disconnecting the cable, remove the battery connection first and then disconnect the receiver.

No antenna is provided with the equipment. For the most satisfactory reception over a narrow band of high frequencies, a doublet or tuned antenna with a balanced leadin is recommended. The two terminals marked "A" at the rear of the receiver are used for the antenna connection. Both terminals are used for the transmission-line leadin from the recommended type of antenna. If a single-wire antenna is used, it should be connected to one of the terminals marked "A" and the other terminal should be connected to a good ground, which is available at the thumbscrews, at the rear, that hold the dust cover on the receiver.

A terminal board marked PHONO-SPKR-PHONES, at the rear of the receiver, provides terminals for the connection of a loud-speaker, 600-ohm audio transmission line, recorder, or headphones. A headphone

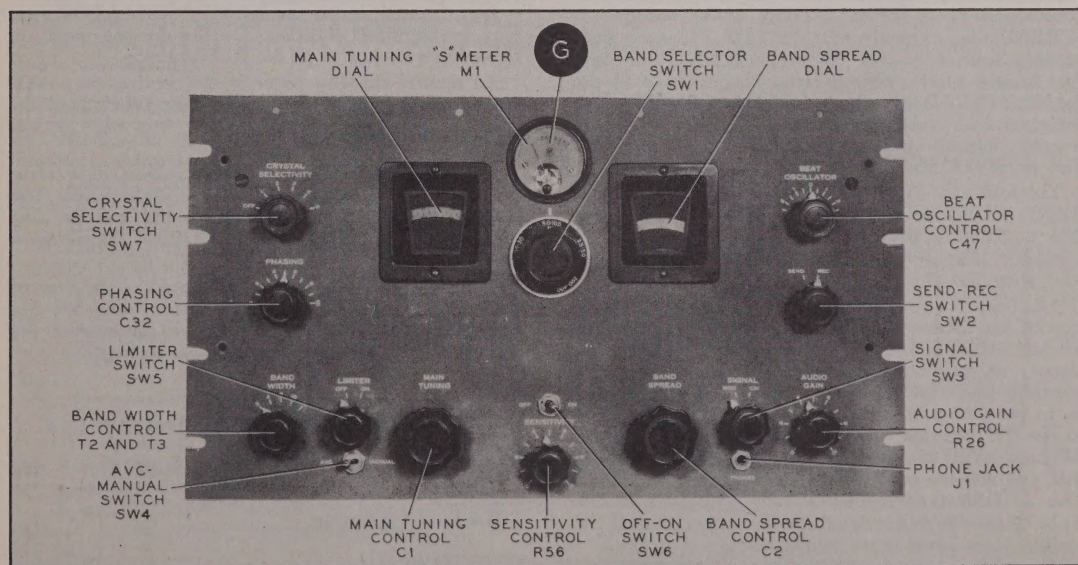


Figure 6. Radio Receiver, Front View, Showing Location of Controls

jack marked PHONES is located under the SIGNAL switch on the front panel. The total power output is about 10 watts. The undistorted power output is in the neighborhood of three watts, with distortion increasing as the power output is increased.

The radio receiver operates over the frequency ranges of 100—400 kc. and 2500—20,000 kc., and is designed to receive both modulated and c-w signals. The operating frequency range is divided into five bands. Each band is marked on an aluminum dial located on a band-selector switch, SW1. See figure 6. The frequency band to be used is obtained by rotating the band switch until the band desired is just beneath the indicator line etched on the panel, just above the band-switch dial.

Located to the left of the band-selector switch is the MAIN TUNING dial and window, and below it is the MAIN TUNING control (E11). Rotating the band switch to the desired band will cause the proper calibrated dial to appear in the MAIN TUNING window. Rotating the MAIN TUNING control will rotate the MAIN TUNING dial; the selected frequency should be aligned with the hairline indicator on the window. The dial calibration per division of dial rotation for each of the five bands is as follows:

BAND	CALIBRATION
100—200 kc.	2 kc. per division
200—400 kc.	5 kc. per division
2.5—5.0 mc.	50 kc. per division
5.0—10 mc.	100 kc. per division
10—20 mc.	100 kc. per division

A BAND SPREAD dial is located to the right of the MAIN TUNING dial, and the BAND SPREAD control (E13) is located directly under the BAND SPREAD dial. The BAND SPREAD dial has a scale reading from 0 to 100. With the MAIN TUNING dial located at the desired frequency, rotation of the BAND SPREAD dial from 100 toward 0 will reduce the operating frequency a number of kc., the exact number depending upon how far the BAND SPREAD dial is moved, and the frequency band in operation.

The OFF-ON switch (SW6) is located beneath the BAND SWITCH; when this switch is thrown to the ON position, it puts the receiver into operation by applying primary power to the power-supply unit used with the receiver.

The type of signal received will determine the position of the SIGNAL switch (J1), located to the right of the BAND SPREAD dial. For phone (modulated signal) reception the switch should be in the MOD position, and for code reception the switch should be in the CW position. When the SIGNAL switch is in the CW position, the BEAT OSCILLATOR control (E17), located to the right of the BAND SPREAD dial, controls the pitch of the audio output frequency. The AUDIO GAIN control (E15), located to the right of the SIGNAL switch, controls the level of the audio output heard in the loud-speaker.

Located to the left of the MAIN TUNING control is the AVC-MANUAL switch (SW4). When this switch is in the MANUAL position, the SENSITIV-

ITY control (E12), located beneath the ON-OFF switch, controls the gain of the receiver. For weak signals the SENSITIVITY control should be set between 7 and 10; for stronger signals the control should be set to a lower reading. When the AVC-MANUAL control is in the AVC position, the gain of the receiver is controlled automatically to produce a constant level of audio independent of signal strength, and the "S" meter (M1), located above the band-selector switch, is used as a tuning guide to indicate the accuracy of the tuning. When a signal is tuned in, the highest reading obtainable on the "S" meter indicates the point of best reception.

The LIMITER switch (E10), located above the AVC-MANUAL switch, is used to subdue noise interference (when severe), which may come in with the received signal. This condition is most apparent on the higher frequency bands.

The degree of selectivity and the fidelity of reception can be controlled by means of the BAND WIDTH control (E9), located to the left of the LIMITER switch. This control is calibrated in kilocycles of band width, with the scale reading from 3 to 16 kc.

For the reception of code signals, a greater degree of selectivity may be desired to eliminate interference from adjacent-channel code stations. Increased selectivity may be obtained by means of a CRYSTAL SELECTIVITY switch (E17) and a PHASING control (E16), located above the BAND WIDTH control. When the CRYSTAL SELECTIVITY switch is in the OFF position, the selectivity circuit and PHASING control are not effective.

When the receiver is used in a communications system with a transmitter, the receiver will be disabled automatically during transmissions if the two terminals marked RELAY at the rear of the receiver are properly connected to the system. The receiver can be disabled manually by moving the SEND-REC switch, located under the BEAT OSCILLATOR control, to the SEND position. During normal operation this switch should be in the REC position.

To remove the dust cover of the receiver or power-supply unit, unscrew the thumb nuts which hold the cover to the front panel and the rear edge of the chassis.

All of the receiver circuits are located in the receiver unit. Figure 7 shows the top view of the receiver. The power-supply unit contains all of the rectifier and power-supply components, figure 8 shows the top view of the power-supply unit.

The "S"-meter adjustment is located at the rear of the receiver, next to the 2nd-detector tube, V8. See figure 6. This adjustment is used in calibrating the meter reading with respect to signal strength.

LESSON PLAN No. 2

TIME ALLOTTED: 1 HR.

SUBJECT

General Description.

OBJECTIVE

To describe Radio Receiver BC-779-B and Power Supply Units RA-74-C, RA-84-B, and RA-94-A.

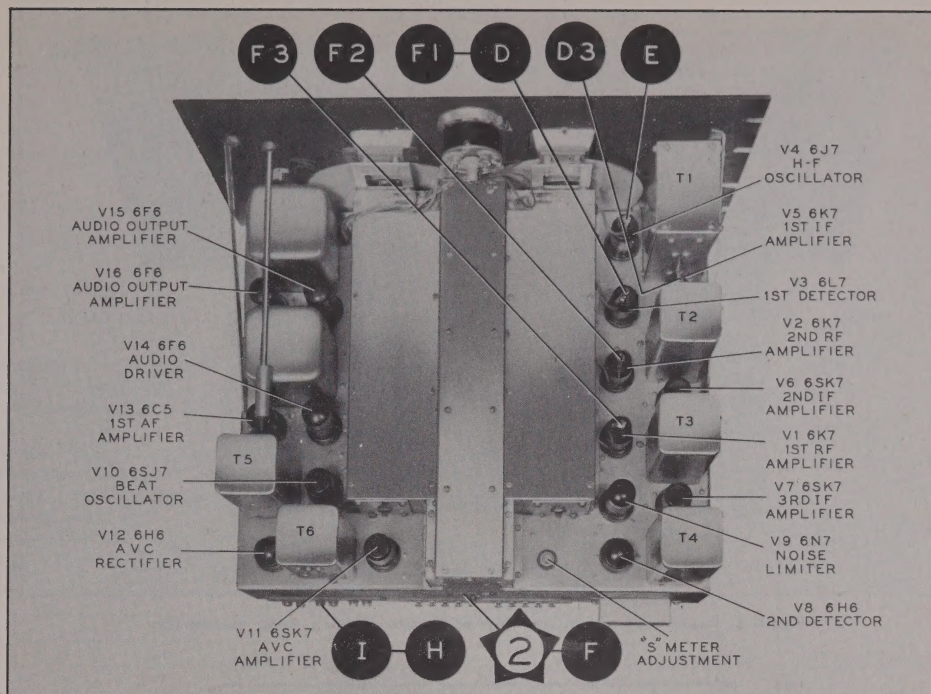


Figure 7. Radio Receiver, Top View of Chassis, Showing Major Components and the Locations of Test Points

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INTRODUCTION

The BC-779-B is a communications-type receiver which uses 16 tubes in an advanced-type receiver circuit. It is designed to receive both c-w and audio-modulated signals.

SUBJECT MATERIAL

Describe the equipment fully and show it to the students; elaborate on the following points:

1. Official nomenclature and functional title of receiver and power supplies.
2. Differences in power-supply units.
3. Cabling diagram shown in figure 4 (to be drawn on board or wall chart prior to lecture).
4. Battery-supply cabling diagram shown in figure 5.
5. Color-code chart for cable connections to battery.
6. Connection of antenna and types of antennas used.
7. Speaker and headphones connections.
8. Frequency bands and dial calibration.
9. Location and purpose of each control, dial, jack, and switch; mention the official name of each as indicated on the front panel.
10. Location and function of each major component on the top of the receiver chassis (refer to figure 7).
11. Location and function of each major component on the top of the power-supply unit (refer to figure 8).

CONCLUSIONS

Radio Receiver BC-779-B can be used with any one of three types of power-supply units or, when necessary, it may be used with a battery supply. The receiver is a fairly complex type of communications receiver, having many desirable features, such as band spread, crystal selectivity, crystal phasing, and noise limiting. The large power output makes it possible for the receiver to feed a number of headphones or speakers, with no noticeable distortion.

ORAL QUIZ

1. What are the two ways of mounting the equipment?
2. What are the power inputs that can be used with the equipment?
3. What frequency bands does the equipment operate on?
4. What is the purpose of the BAND SPREAD control?
5. What types of antennas may be used?
6. What is the undistorted power output? The maximum power output?
7. When is the SEND-REC switch used?
8. How is the SENSITIVITY control used?
9. What switch places the receiver in operation for the reception of code signals?
10. On what frequencies is the action of the noise limiter the most noticeable?

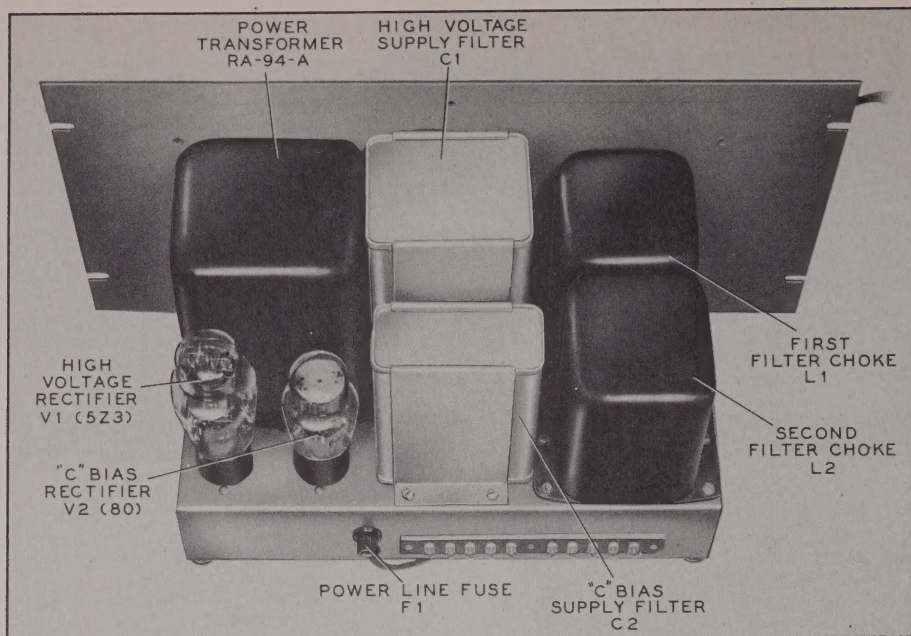


Figure 8. Power-Supply Unit, Top View of Chassis, Showing Major Components

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EXPERIMENT No. 1

SUBJECT

Identification of components.

TIME ALLOTTED: 2 HR.

OBJECTIVE

To become familiar with the physical layout of all components, controls, etc. of the BC-779-B radio receiver and power-supply unit and the manner in which both units are interconnected.

EQUIPMENT REQUIRED

- 1 Radio Receiver BC-779-B.
- 1 Power Supply Unit RA-74-C, RA-84-B, or RA-94-A.
- 1 Loud-speaker.
- 1 Interconnecting cable.

INSTRUCTIONS

Make certain that the power input plug is disconnected. Do not handle the equipment until the start of the experiment. Perform each step as outlined in the procedure.

PROCEDURE

1. Make a sketch of the rear of the receiver and power-supply unit; show clearly all terminal strips, cables, fuses, etc. and label each item with its reference symbol and functional name.

2. On the front view of the receiver in figure A are shown the locations of all the controls, meters, dials, switches, etc. Give the reference symbol and name of each of these items in the following chart:

ITEM No.	REFERENCE SYMBOL	NAME
1		
2		
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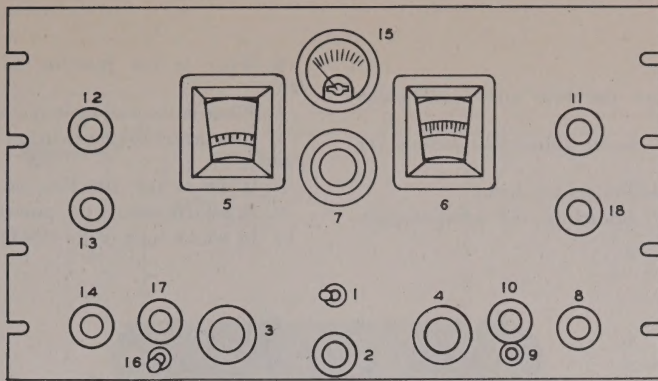


Figure A.

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3. Remove the dust cover of the receiver as follows:
 - a. Loosen the knurled thumb nuts that retain the cover by turning them in counterclockwise direction.
 - b. Lift the chassis from the cover.
4. Referring to figure B, locate the items numbered and give the reference symbol and function of each in the following chart:

ITEM No.	SYMBOL REFERENCE	FUNCTION
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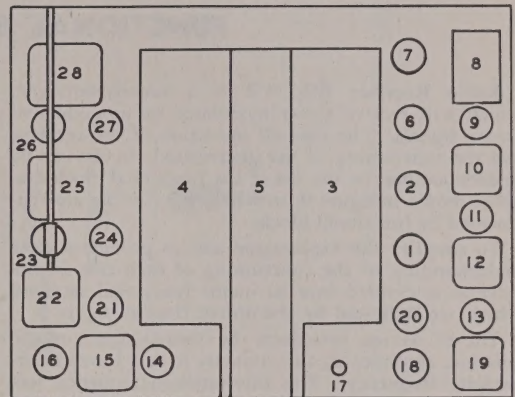


Figure B.

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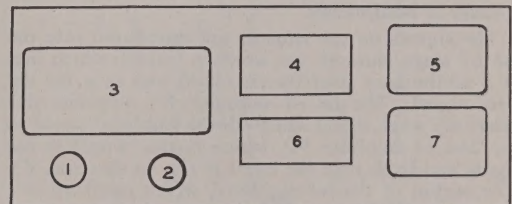


Figure C.

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ITEM No.	REFERENCE SYMBOL	FUNCTION
1		
2		
3		
4		
5		
6		
7		

5. Remove the dust cover from the power-supply unit, using the same procedure given in step 3 for the removal of the receiver dust cover. Referring to figure C, locate the items numbered and give the reference symbol and function of each in the following chart:

6. Reassemble the receiver and power-supply units.

CONCLUSIONS

1. In which unit are the fuse and fuse holder located?
2. Where is the "S" meter adjustment located on the receiver?
3. How many i-f transformers are there?
4. Which tubes are located in the power-supply unit?

5. What is the function of the interconnecting cable?
6. What is the full-scale reading on the "S" meter?
7. How many toggle switches are there on the front panel?
8. What is the function of each tuning dial?
9. In which unit is the power transformer located?
10. In which unit is the ON-OFF switch located?

LECTURE No. 3

FUNCTIONAL BLOCK ANALYSIS

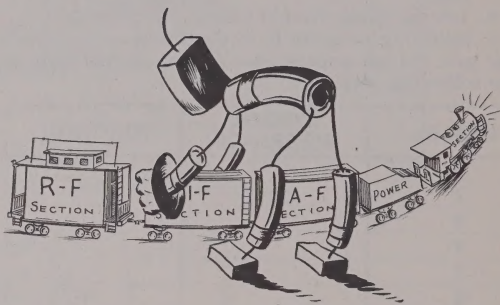
Radio Receiver BC-779-B is a superheterodyne, which will receive either modulated or unmodulated (c-w) signals. The over-all operation of the receiver and the functioning of the interrelated circuits can be understood best by the use of the functional block diagram shown in figure 9, in which the circuits are represented by functional blocks.

To simplify the explanation and to provide a clear understanding of the functioning of each circuit, the receiver is divided into its major functional sections, which are indicated by the dotted lines in figure 9.

The r-f section pre-selects the desired signal on the antenna, amplifies it, and converts it to a lower intermediate frequency. The intermediate-frequency section selects the intermediate frequency, amplifies it, and produces an audio frequency which is fed to the audio-frequency section. The audio-frequency section amplifies the audio signal sufficiently to drive a loud-speaker or headphones.

The signals on the antenna are introduced into the 1st r-f stage through the antenna circuit which acts as a preliminary selective circuit to pass only the desired signal. The 1st r-f amplifier, V1, amplifies this relatively weak signal and feeds the amplified signal to the 2nd r-f amplifier V2, which further amplifies the signal and feeds it to the input of the 1st detector, V3. The output of the h-f oscillator, which oscillates at a frequency 465 kc. above the frequency of the signal to which the r-f stages are tuned, is also fed to the 1st-detector stage. (Assuming that the receiver is operating in the 2.5-to-5.0-mc. band and the signal received is 3.0 mc., modulated with a 1000-cycle audio signal, the local-oscillator frequency will be 3.465 mc.). These two frequencies are mixed in the first detector or mixer stage, and the output will contain the 465-kc. beat or difference frequency plus a number of other frequencies. The output of the 1st detector is tuned to pass only the difference frequency, which is modulated with the original 1000-cycle audio signal present on the carrier signal.

The i-f amplifier consists of three stages: the 1st i-f amplifier, V5, the 2nd i-f amplifier, V6, and the third i-f amplifier, V7. All of these stages will amplify the i-f signal (465 kc.) and provide a high degree of selectivity and stability. Located between the 1st-detector and the 1st i-f amplifier is a crystal-filter circuit, which acts as a very selective, high-Q tuned circuit.

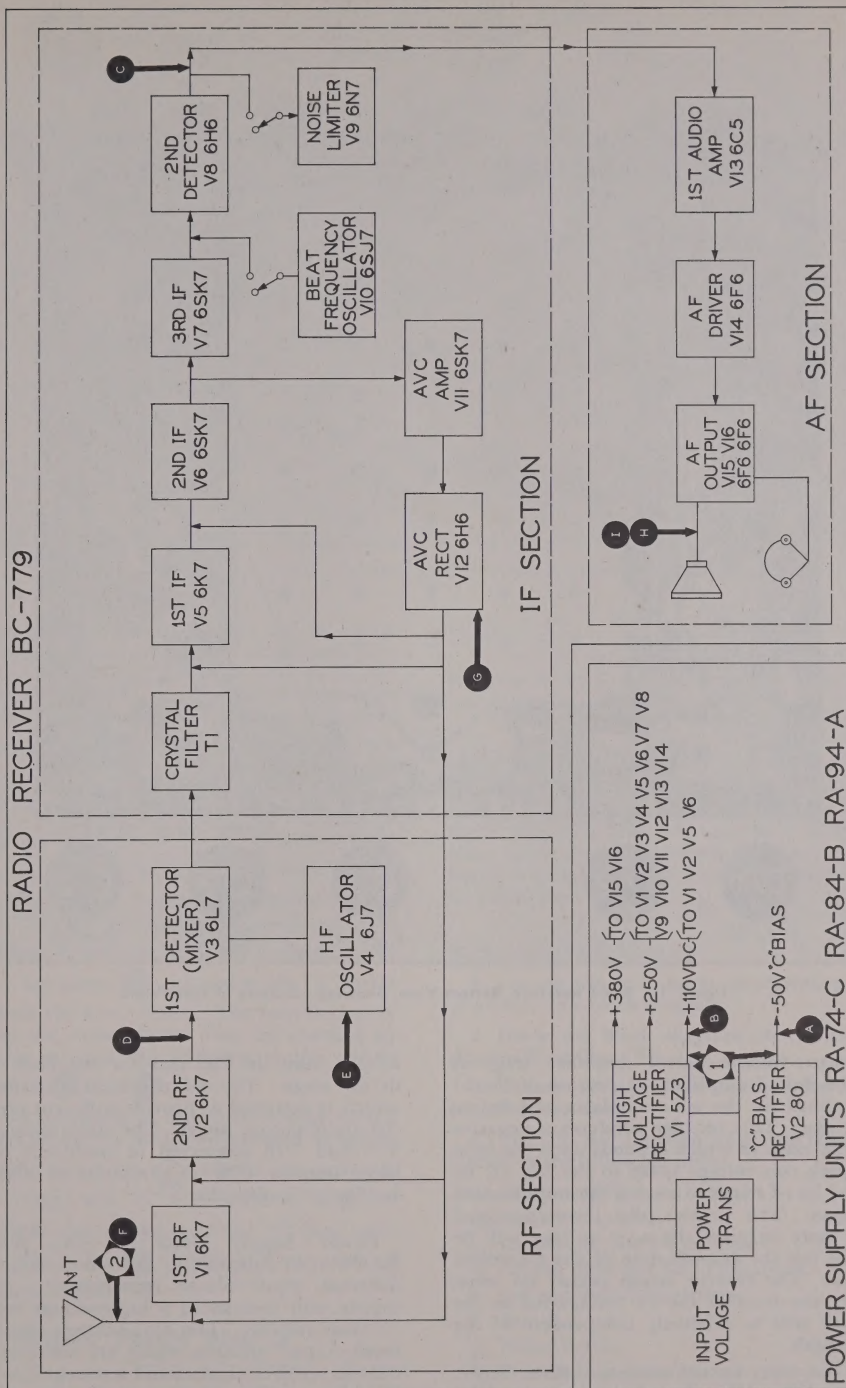


The selectivity of this circuit can be varied in definite steps by the CRYSTAL SELECTIVITY switch on the front panel. The selectivity characteristics can be further controlled by means of the PHASING control located on the front panel. When the CRYSTAL SELECTIVITY switch is set at OFF, the crystal is short-circuited, and the i-f signal in the output of the 1st detector is passed directly to the input of the 1st i-f stage.

The greatly amplified i-f signal from the 3rd i-f transformer is fed to the 2nd detector, V8. This stage rectifies the i-f signal, removes the i-f component, and passes the audio-modulation component (in this case, the 1000-cycle audio signal) onto the 1st audio stage for further amplification.

The noise-limiter stage operates in conjunction with the 2nd detector to remove any noise of short duration from the audio signal. Interference such as that caused by auto ignition systems will be reduced considerably. The LIMITER switch places this stage in operation.

When the SIGNAL switch is placed in the CW position, the beat-frequency oscillator (BFO) is put in operation. This oscillator provides an r-f signal of approximately 465 kilocycles. This signal is introduced into the input circuit of the 2nd detector, and is mixed with the i-f signal from the 3rd i-f amplifier. These two frequencies heterodyne, producing a beat, or difference frequency, in the output of the 2nd detector. This beat frequency can be controlled by adjusting the frequency of the BFO with the BEAT OSCILLATOR control on the front panel.



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Figure 9. Radio Receiver and Power-Supply Unit, Functional Block Diagram

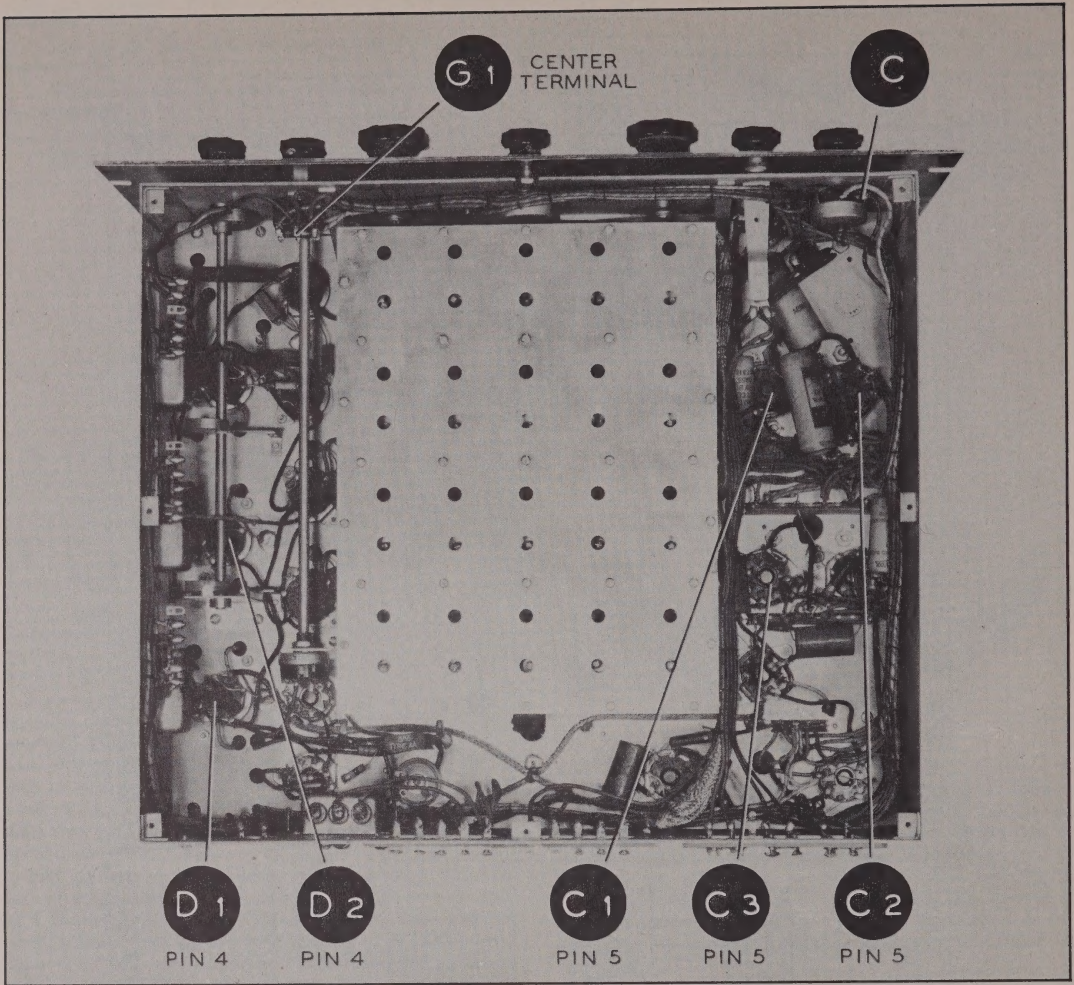


Figure 10. Radio Receiver, Bottom View, Showing Locations of Test Points

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The automatic-volume-control amplifier stage is coupled to the 3rd i-f amplifier. A portion of the i-f signal is amplified by the a-v-c amplifier and fed to the a-v-c rectifier. This rectifier produces a negative d-c voltage, the value of which depends upon the level of the i-f signal; this voltage is fed to the 2nd i-f, 1st i-f, 2nd r-f, and 1st r-f stages to control the amplification of these stages. The greater the incoming-signal strength the more negative the a-v-c voltage will be and hence, the less the amplification of the controlled stages will be. The reverse action occurs on weak signals. Thus, the level of the i-f voltage fed to the second detector will be relatively independent of the r-f carrier strength.

The audio-frequency section consists of three stages: the 1st a-f amplifier, V13, the a-f driver stage, V14, and the audio-output stage, V15 and V16. The 1st a-f stage is a voltage amplifier which amplifies the audio

output from the 2nd detector and feeds it to the a-f driver stage. The a-f driver is a power amplifier, which is designed to provide sufficient power to drive the audio-output stages. The audio output consists of V15 and V16 connected in push-pull to provide a large output, with a minimum of distortion to a headset or loudspeaker.

Power Supply Units RA-74-C, RA-84-B, and RA-94-A all function in the same manner, but have different input-voltage requirements. Each power-supply unit consists of a high-voltage rectifier and a "C"-bias rectifier. The high-voltage rectifier provides three output voltages, which are distributed throughout the receiver as plate and screen-grid voltages. The "C"-bias rectifier provides a negative voltage, which is used in the 1st r-f, 2nd r-f, 1st i-f and 2nd i-f stages for bias and sensitivity control.

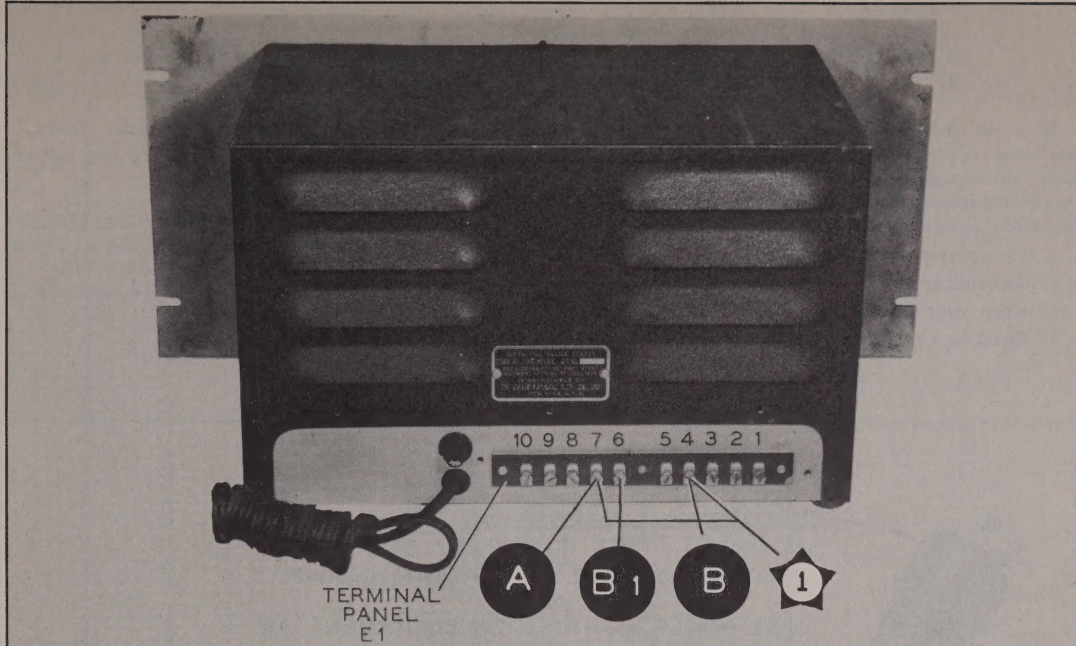


Figure 11. Power-Supply Unit, Rear View, Showing Locations of Test Points

144

The over-all operation of the receiver and the operation of the major functional sections or portions of a functional section may be checked by the use of certain test points. See figures 6, 7, 9, and 10. The over-all receiver is checked by applying the proper signal to major test point ②, located at the antenna. To check the audio-amplifier section, key test point C located at the input of the 1st a-f amplifier is used. Key test point D at the input of the 1st detector checks the operation of the i-f section. Key test point E in the h-f-oscillator circuit checks the operation of the h-f oscillator. The r-f section is checked by applying the proper signal to key test point F, located at the antenna. Key test point G, located at the "S" meter is used to check the a-v-c circuit. The beat-frequency oscillator and the noise limiter may be checked by operating these circuits and listening to the output at key test points H and I.

To check the operation of the power-supply unit, a number of test points are used, as illustrated in figures 9 and 11. Major test point ① checks the operation of the high-voltage and "C"-bias rectifiers. Key test point A checks the operation of the "C"-bias rectifier, and key test point B checks the operation of the high-voltage rectifier.

LESSON PLAN No. 3

TIME ALLOTTED: 1 HR.

SUBJECT

Functional block analysis.

OBJECTIVE

To explain the functions and interrelations of all the circuits in Radio Receiver BC-779-B through the use of a functional block diagram.

INTRODUCTION

Radio Receiver BC-779-B is a complex superheterodyne. By representing each functional circuit as a block diagram, the functions and interrelations of these circuits can be understood more easily. Thus a better foundation for the analysis of the circuits may be established.

SUBJECT MATERIAL

1. Discuss the purpose in representing each circuit as a block in a block diagram.
2. Draw the block diagram on the blackboard or display Wall Chart No. 1.
3. Discuss the operation of the receiver by major functional sections.
4. Explain the function and interrelation of each circuit in the following order:
 - a. 1st r-f amplifier.
 - b. 2nd r-f amplifier.
 - c. 1st detector and h-f oscillator.
 - d. Crystal filter and 1st i-f amplifier.
 - e. 2nd and 3rd i-f amplifiers.
 - f. 2nd detector.
 - g. Noise limiter.
 - h. Beat-frequency oscillator.
 - i. A-v-c circuit.
 - j. 1st a-f amplifier.

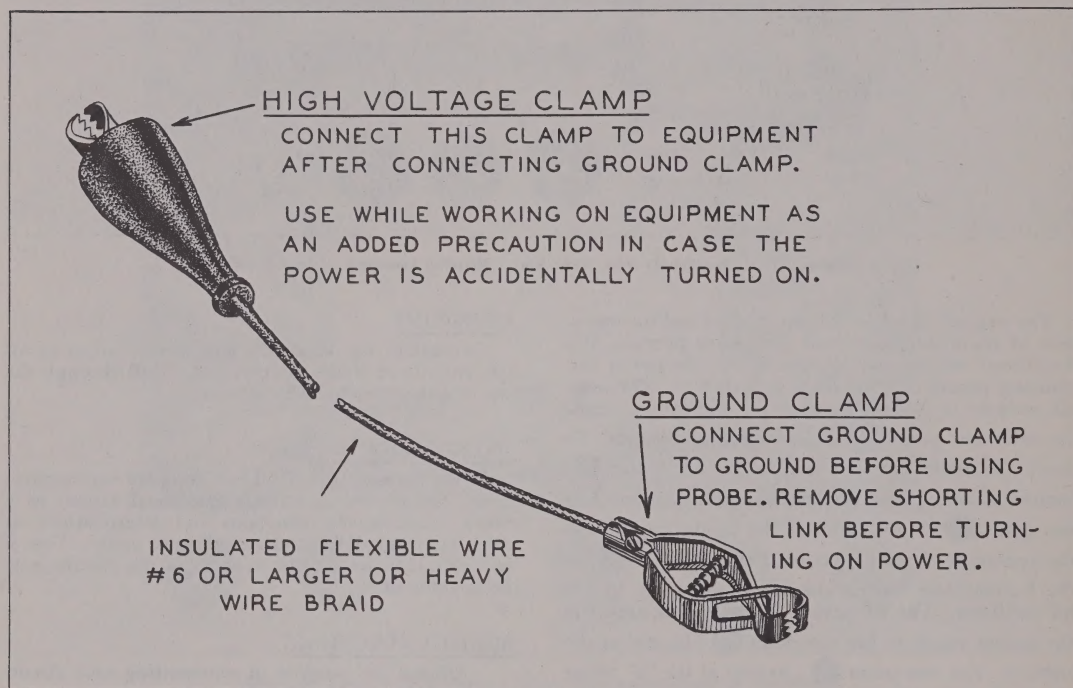
▶ SAFETY PRECAUTIONS ◀

It is the duty of all personnel engaged in the installation, operation, and maintenance of this equipment, or engaged in the training of other personnel on this equipment, to become familiar with the following safety precautions:

1. Do not rely on safety devices.
2. Use rubber gloves when applicable.
3. Keep your feet clear of objects on the floor.
4. Stand on a good rubber mat.

5. Keep one hand behind you, or in your pocket.
6. Have another person, qualified in first aid for electrical shock, present at all times.

Remember that men are always injured or killed by high-voltage equipment which is assumed to be off. Take nothing for granted. Make certain that the power is off by securing the power-line switch in its OFF position.



TP-9692

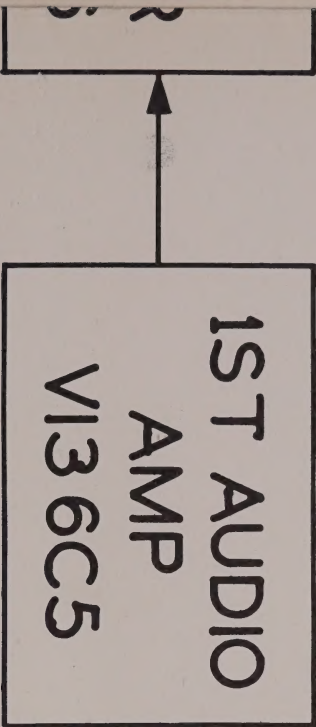
▶ FIRST AID ◀

Do These Three Things First in Any Emergency Requiring First Aid

1. Send for a doctor or carry the victim to a doctor.
2. Keep victim warm, quiet, and flat on his back.
3. If breathing has stopped, apply artificial respiration. Stop all serious bleeding.

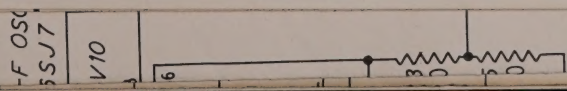
When, from any cause whatever, breathing has stopped, apply artificial respiration immediately and continue WITHOUT STOPPING until normal breath-

ing returns, or a doctor pronounces the victim dead. SPEED IN BEGINNING ARTIFICIAL RESPIRATION IS ESSENTIAL.



WALL CHART No. 1

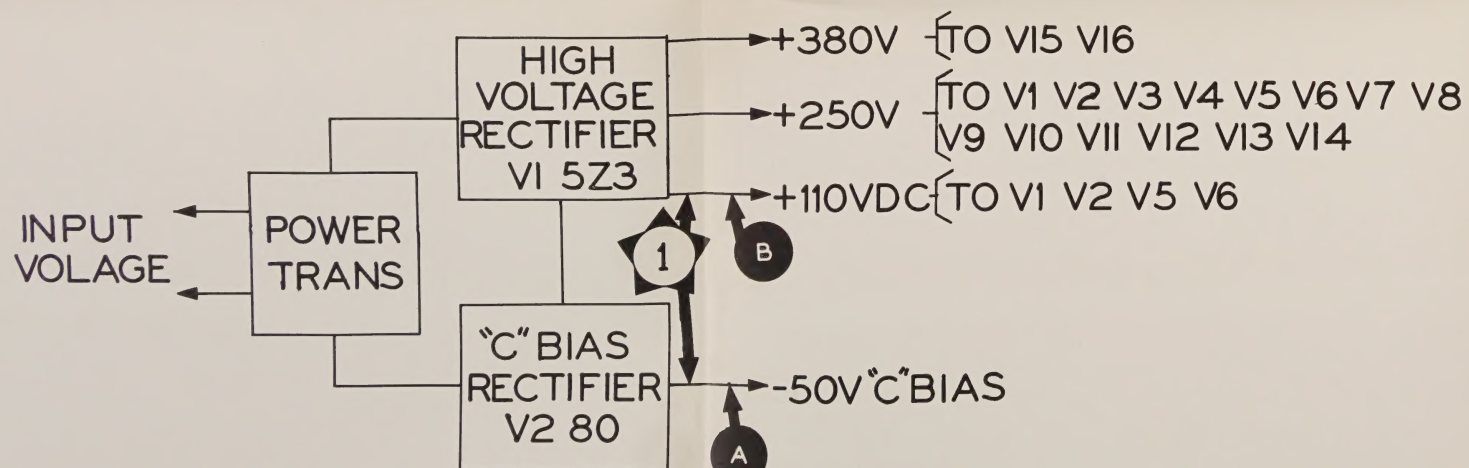
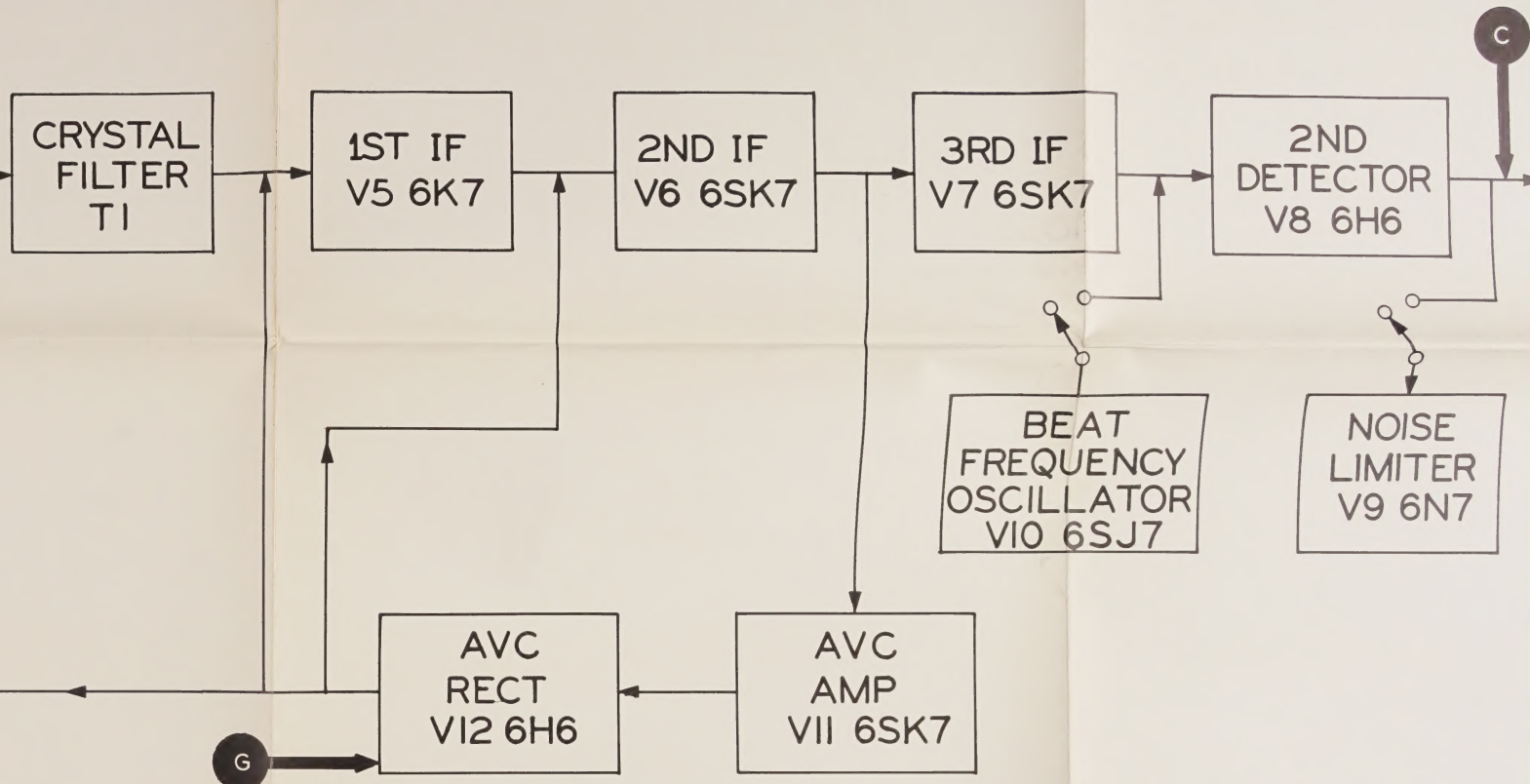
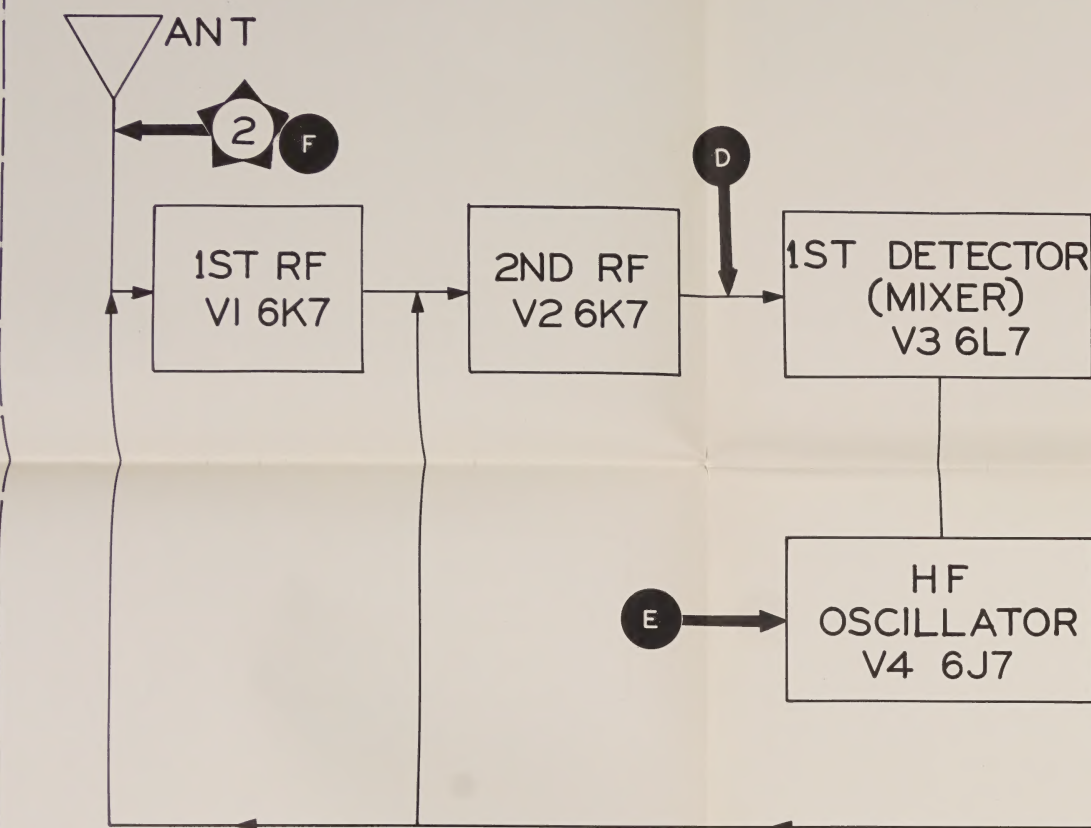
Radio Receiver BC-779-B
and Power-Supply Unit,
Functional Block Diagram



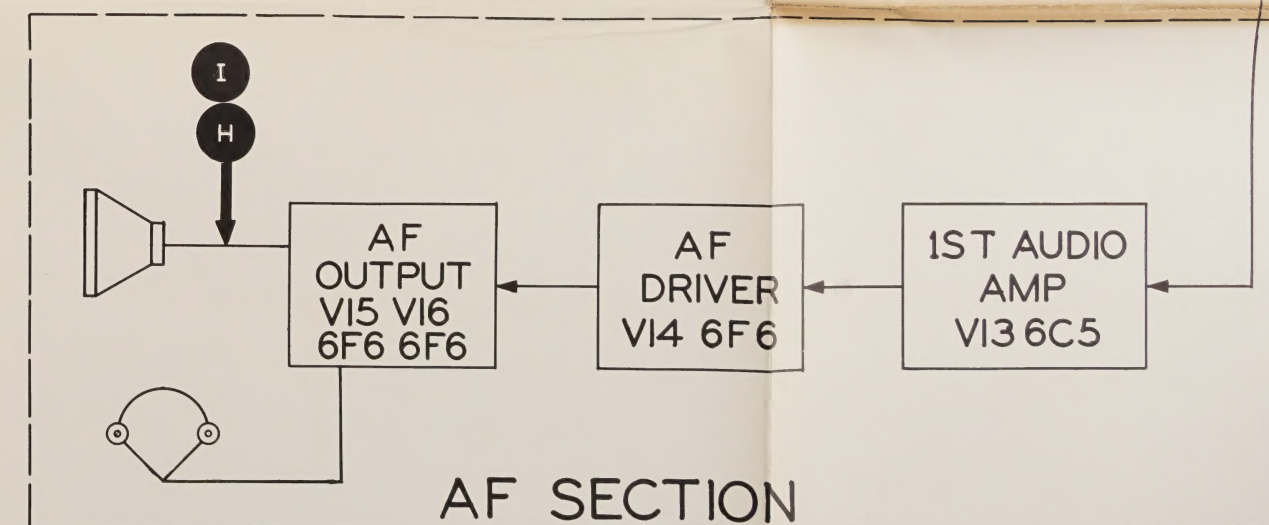
RADIO RECEIVER BC-779

RF SECTION

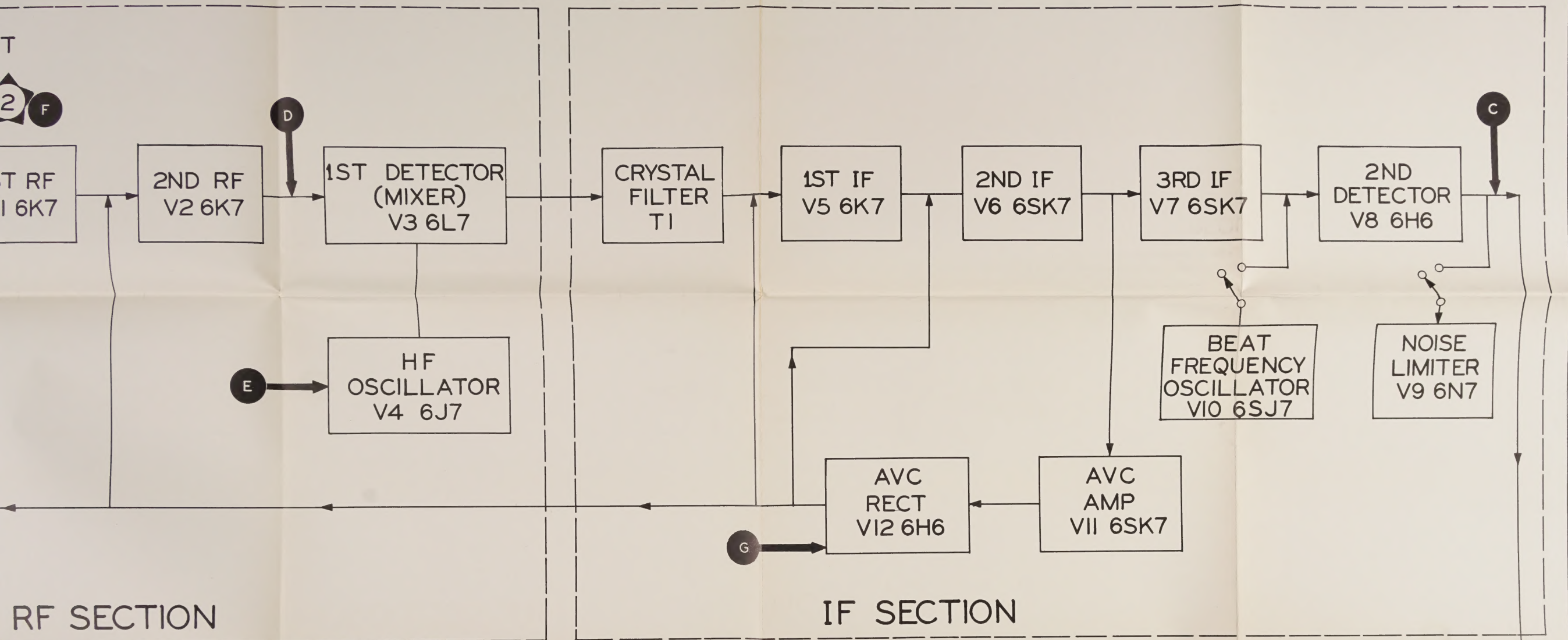
IF SECTION



POWER SUPPLY UNITS RA-74-C RA-84-B RA-94-A

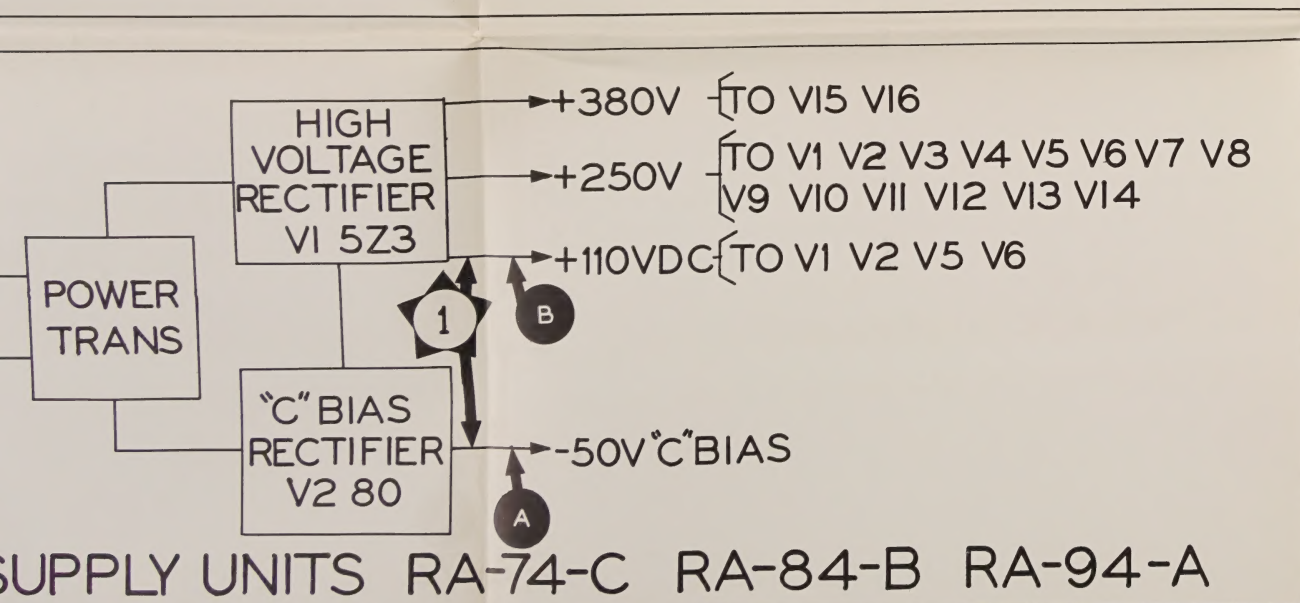


RADIO RECEIVER BC-779

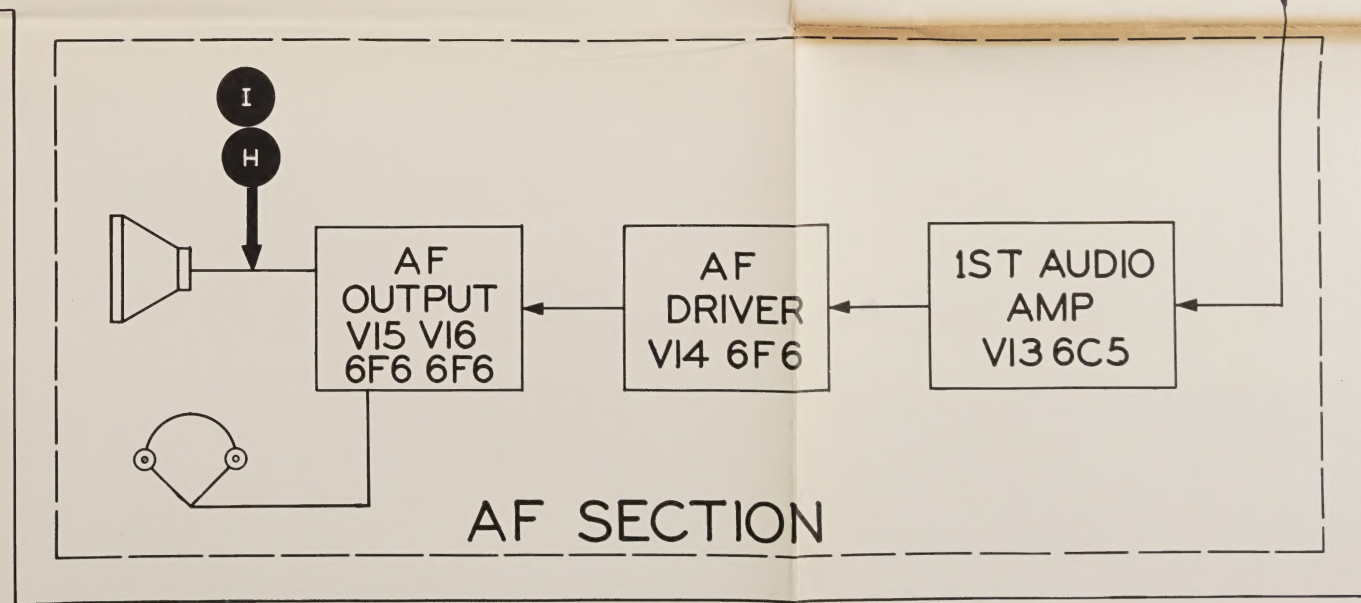


RF SECTION

IF SECTION



SUPPLY UNITS RA-74-C RA-84-B RA-94-A



AF SECTION

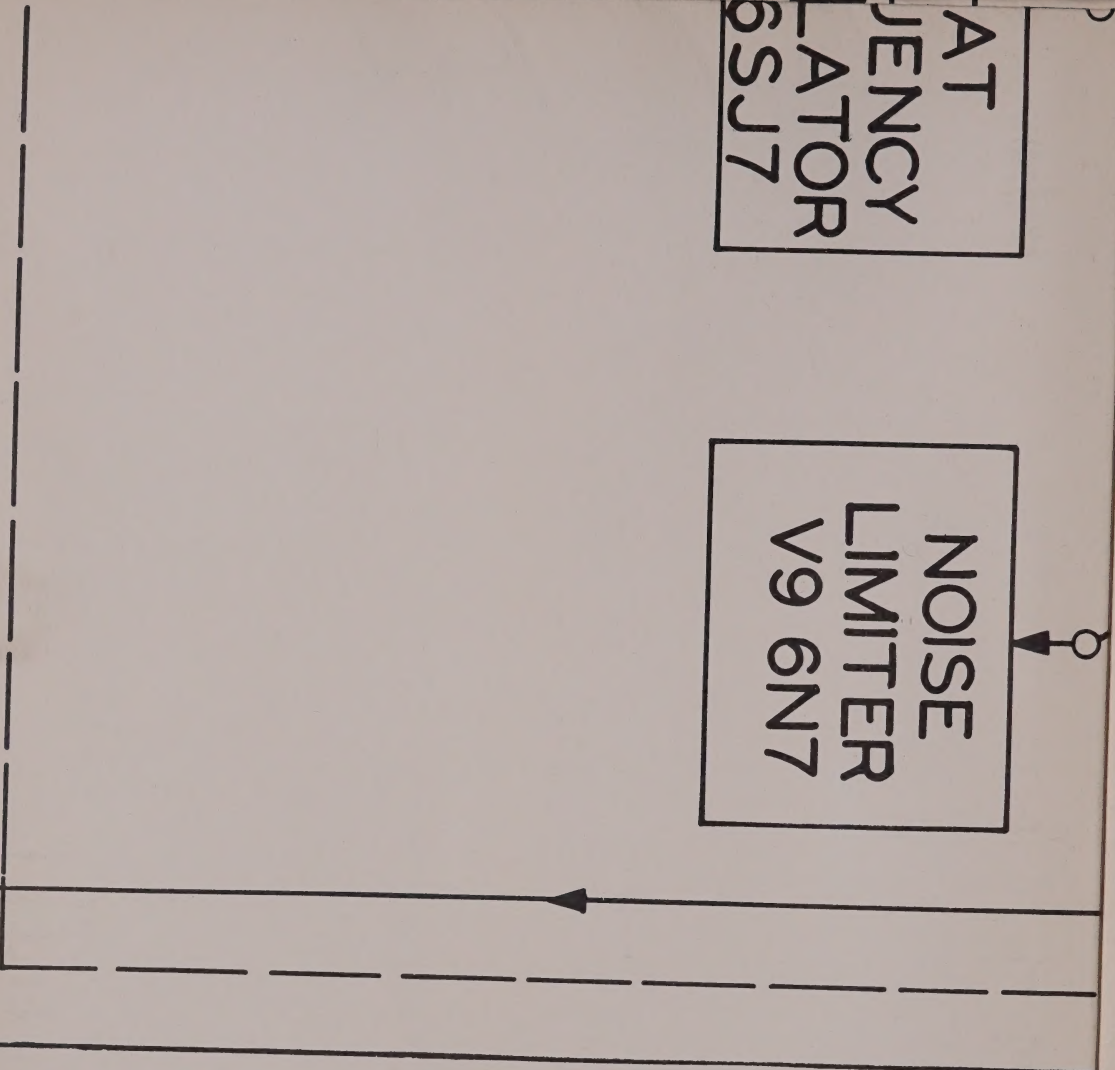


WALL CHART
No. 1

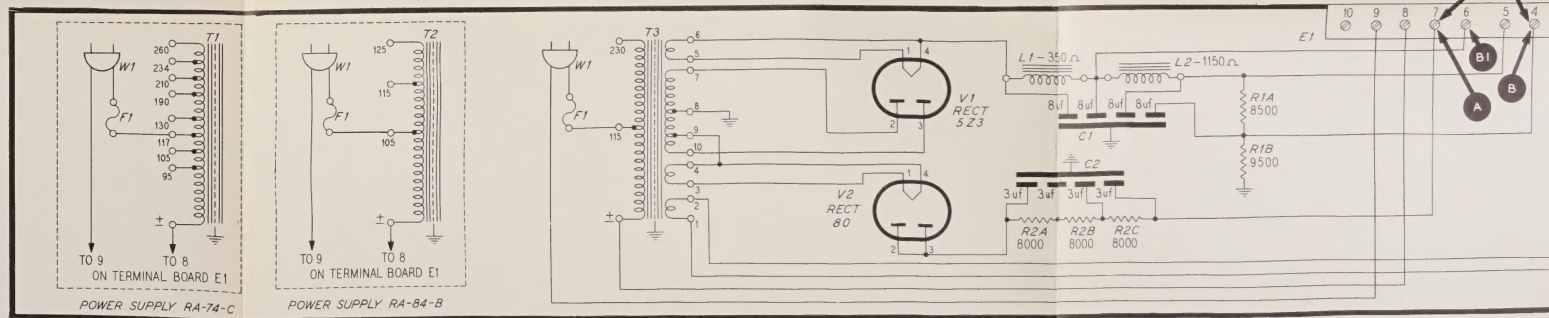
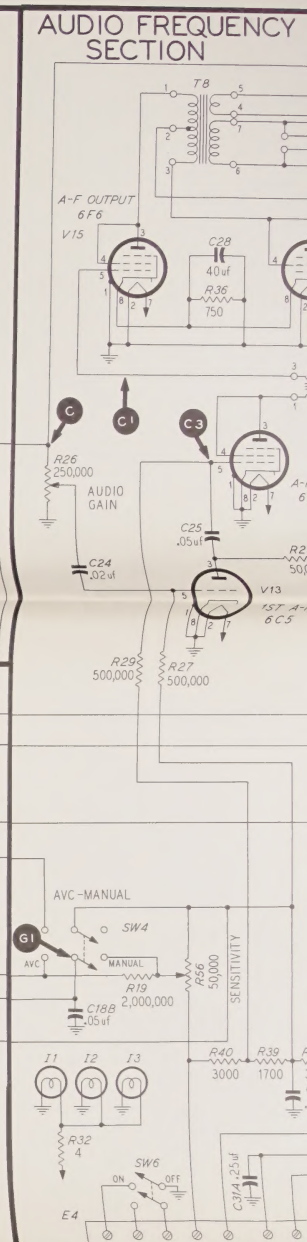
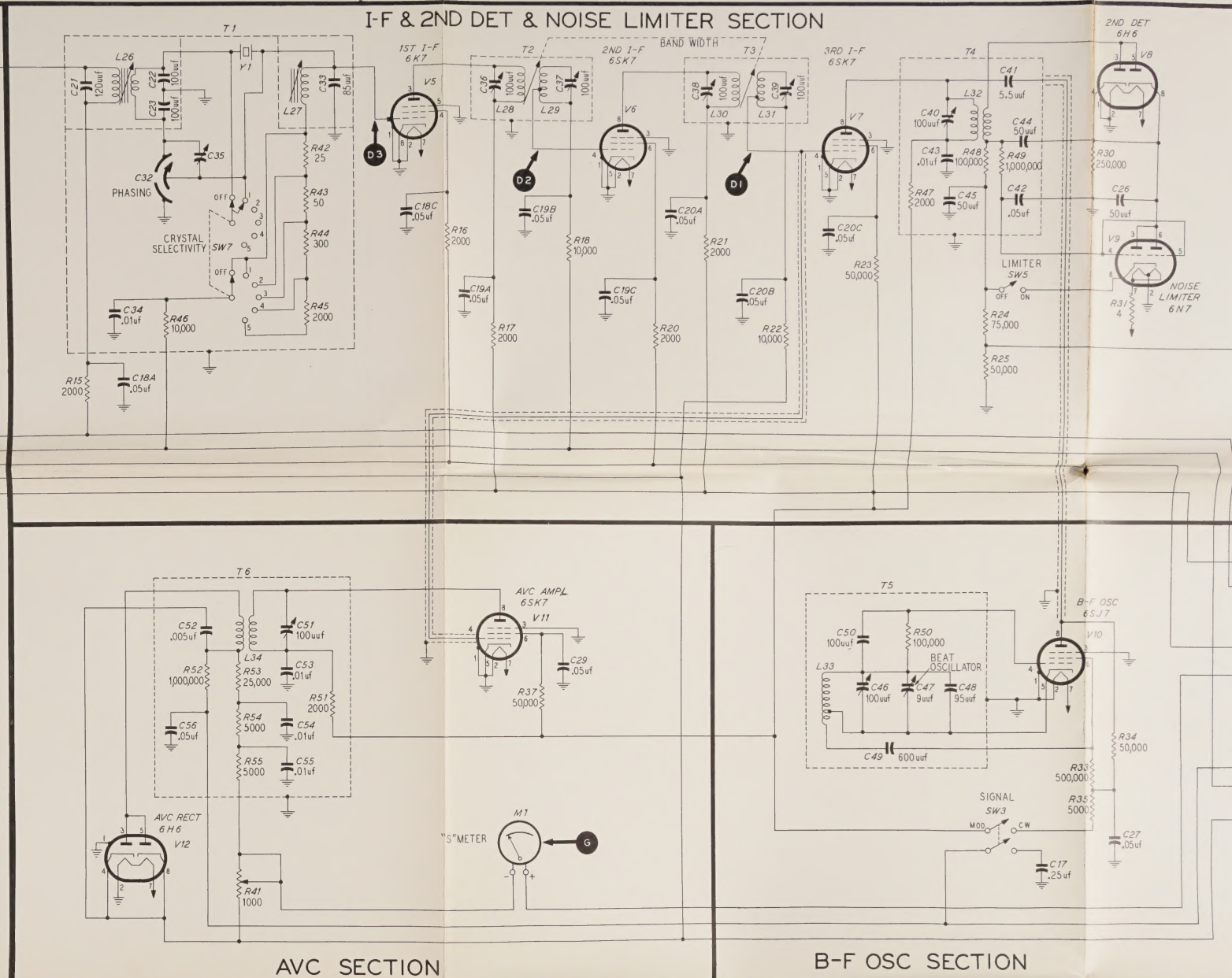
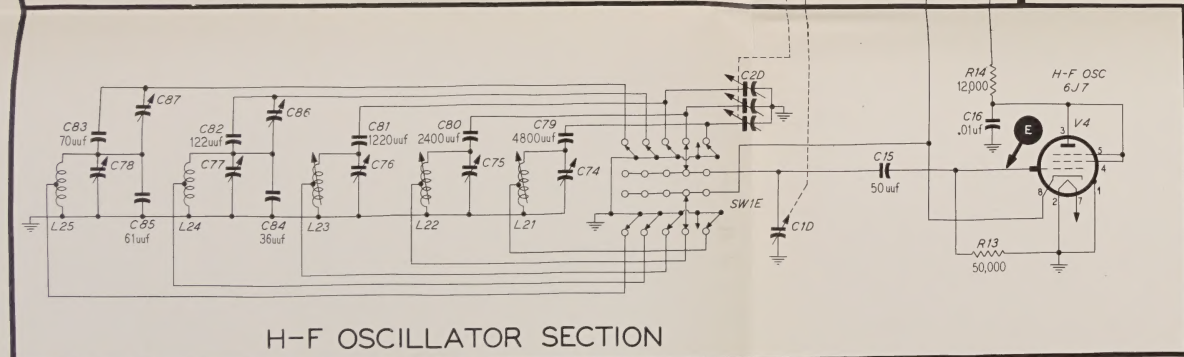
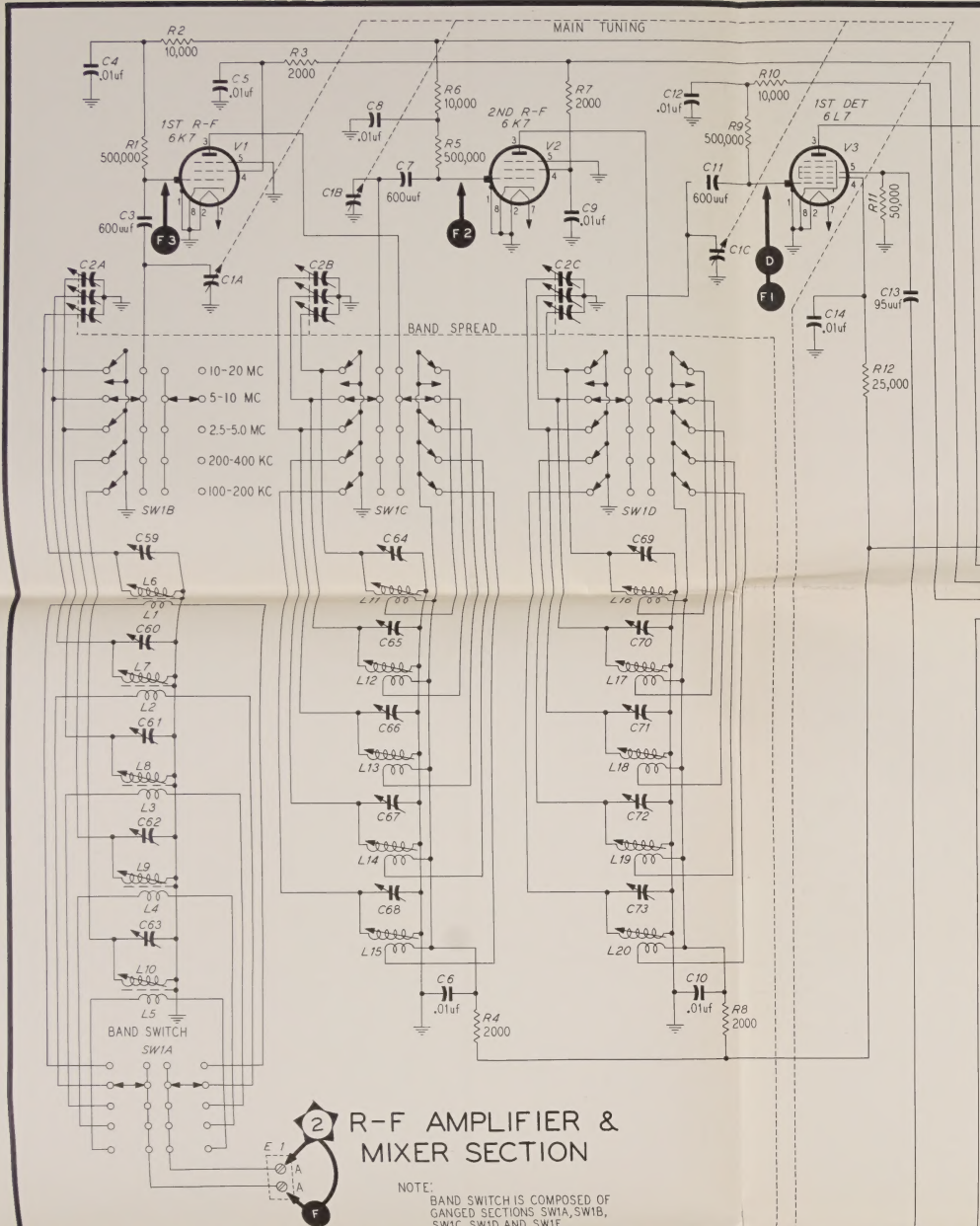
Radio Receiver BC-779-B
and Power-Supply Unit,
Functional Block Diagram

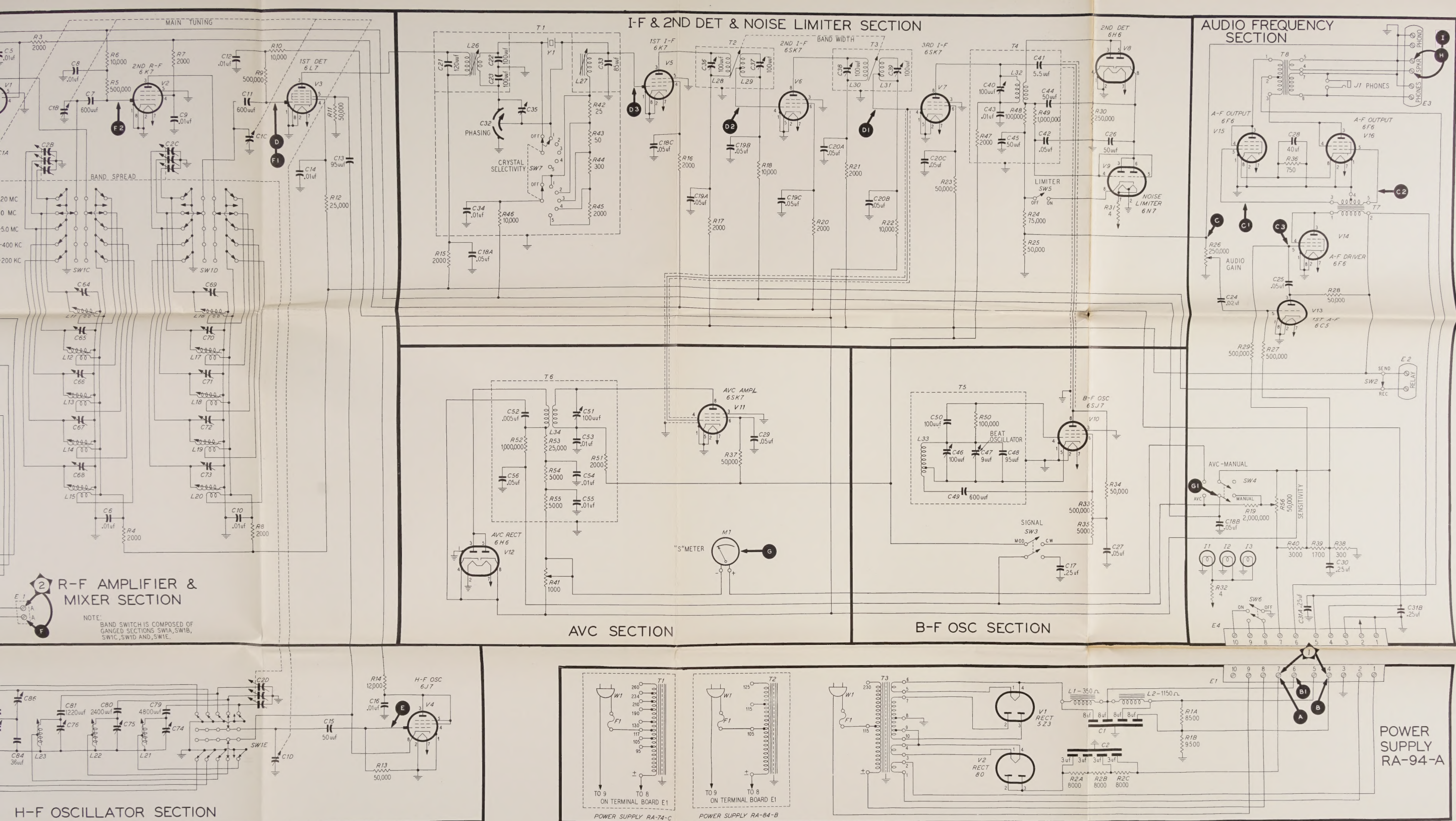
AT
JENCY
LATOR
6S J7

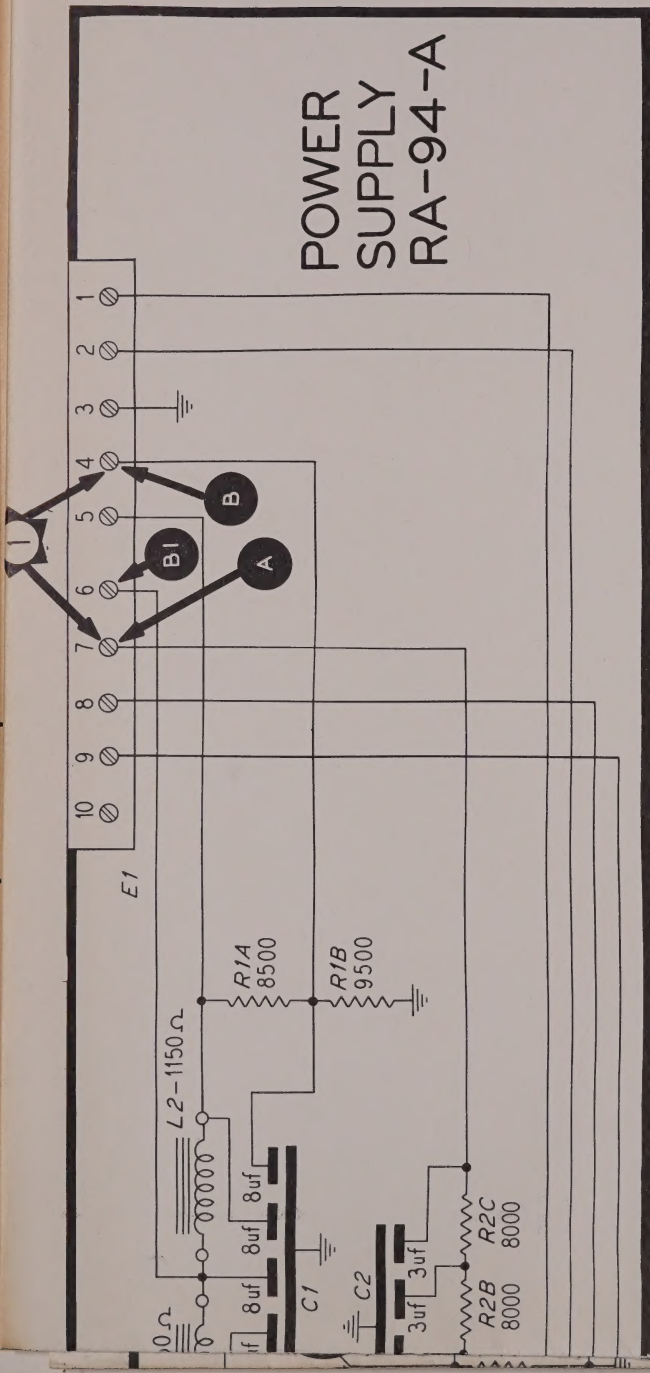
NOISE
LIMITER
V9 6N7









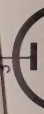


POWER SUPPLY RA-94-A

WALL CHART No. 2

Radio Receiver BC-779-B,
Schematic Diagram, Showing
Test Points

50,000



0.02 μf

ANSWER AND TROUBLE-SHOOTING SUPPLEMENTS

FOR RADIO RECEIVER BC-779-B

ANSWER SUPPLEMENT

EXAMINATION No. 1, PART I

1. d.
2. b.
3. c.
4. d.
5. d.
6. c.
7. b.
8. a.
9. d.
10. b.
11. a.
12. c.
13. b.
14. a.
15. d.
16. a.
17. b.
18. b.
19. b.
20. c.
21. d.
22. a.
23. b.
24. d.
25. a.
26. The BC-779 is used extensively as a communication receiver because it (a) has a balanced-type input circuit, (b) covers the low-frequency and high-frequency communications bands, and (c) receives either phone or c-w signals.
27. The three power-supply units are essentially alike except for variations in input voltages.
28. Rotating the BAND SPREAD dial from 100 to 0 will lower the operating frequency, the amount depending upon how far the BAND SPREAD dial is moved, and the frequency band that is in operation.
29. The "S" meter indicates the accuracy of the tuning; the highest reading obtainable while tuning in a signal is the point of best reception.
30. Refer to figure 9.

EXAMINATION No. 1, PART II

31. c.
32. c.
33. a.
34. a.
35. d.
36. b.
37. a.
38. d.
39. c.
40. a.
41. a.

42. d.
43. c.
44. a.
45. b.
46. The tuned circuits in the r-f amplifier and 1st detector grid circuits are adjusted for maximum output-meter reading, at the low end of each band, by varying the tuning cores in the coils and, at the high end of each band, by varying the trimmer capacitors across the coils.
47. The BEAT OSCILLATOR control is adjusted so that frequency of the beat-frequency oscillator at zero beat with the interfering signal on one side of the desired signal while the PHASING control is adjusted so that the rejection notch eliminates the interfering signal on the other side.
48. If resistor R42 were to become open-circuited, the 1st i-f grid circuit would have no d-c return path to the cathode; therefore, the receiver would be inoperative when the CRYSTAL SELECTIVITY control is in positions 2 through 5.
49. If tube V6 were to become defective, an i-f signal applied to test points **D**, **D3** and **D2** would not produce an output from the receiver.
50. The i-f signal is applied to test point **D**, located at the grid cap of the 1st detector.

FINAL EXAMINATION, PART I

1. b.
2. c.
3. a.
4. b.
5. b.
6. b.
7. a.
8. b.
9. b.
10. d.
11. d.
12. b.
13. a.
14. c.
15. a.
16. d.
17. b.
18. a.
19. d.
20. b.
21. The automatic-volume-control system automatically controls the sensitivity of the r-f and i-f stages to compensate for variations in signal strength due to fading.
22. Three advantages of using an external power supply are: (1) a minimum of hum is introduced into the receiver, (2) the over-all temperature rise is reduced, and (3) better stability is obtained.

23. The proper alignment of the r-f, i-f, a-v-c, and b-f-o circuits determine primarily the degree of sensitivity and selectivity of the receiver.
24. The two factors which may cause improper calibration of the MAIN TUNING dial are poor mechanical dial alignment and improper alignment of the h-f oscillator.
25. By performing the prescribed preventive-maintenance checks many troubles may be prevented and the receiver will be maintained at the best possible operating efficiency.

FINAL EXAMINATION, PART II

26. c.
27. a.
28. b.
29. d.
30. c.
31. a.
32. c.
33. c.
34. d.
35. a.
36. b.

37. b.
38. a.
39. a.
40. b.
41. d.
42. b.
43. c.
44. d.
45. c.
46. Resistor R49 and capacitor C42 in the grid circuit of the noise limiter.
47. Whenever the SIGNAL switch is in the CW position, a .25-mf. capacitor, C17, is automatically added to the a-v-c system.
48. When the SIGNAL switch is placed in CW position, it closes the circuit to the positive 250-volt supply for the plate and screen grid.
49. V15 and V16 are biased by the self-biasing arrangement consisting of capacitor C28 and resistor R36, located in the common cathode lead of the two tubes.
50. Noisy operation of the r-f amplifiers, mixer, or 1st i-f stage is most apt to reduce the signal (plus noise) -to-noise ratio.

TROUBLE-SHOOTING SUPPLEMENT

EXPERIMENT No. 3

1. Disconnect the antenna from antenna terminals AA at the rear of the receiver. Connect a fine piece of wire inconspicuously between the terminals, thus shorting them together. Reconnect the antenna. The receiver will be inoperative on all bands.
2. Replace V2, 2nd r-f amplifier, with a defective tube. If a defective tube is not available, insulate either pin 2 or 7 on the original tube with scotch tape, to simulate an open filament.

EXPERIMENT No. 4

1. Locate capacitor C13 which is connected between pin 5 on V3, the 1st detector, and pin 8 on V4, the h-f oscillator. Disconnect the capacitor lead at pin 8 on V4. This simulates an open coupling capacitor between the h-f oscillator output and the injector grid of the 1st detector. The receiver will be inoperative on all bands.
2. Disconnect the grid clip from the cap on the h-f oscillator tube, V4. Simulate an open grid capacitor by insulating the grid cap with scotch tape, and replace the grid clip. The receiver will be inoperative on all bands.

EXPERIMENT No. 5

1. Disconnect one of the leads of R17, the plate decoupling resistor in the 1st i-f stage, from terminal board E20. This simulates an open plate circuit, removing the supply voltage from the plate. The receiver will be inoperative on all bands.
2. Disconnect the lead from shield can T2, that goes to resistor R18 on terminal board E20. This

simulates an open secondary winding in i-f transformer T2, in the grid circuit of the 2nd i-f tube. The receiver will be inoperative on all bands.

EXPERIMENT No. 6

1. Disconnect the center lead from the terminals on the AUDIO GAIN control, R26, which is located at the rear of the front panel. This simulates a defective AUDIO GAIN control. There will be no audio output from the receiver.
2. Connect a jumper between the grid (pin 4) of the noise-limiter tube, V9, and ground (pin 1). This simulates a shorted condition in capacitor C42. Whenever the LIMITER switch is turned ON, the receiver output will drop to a very low level, and considerable distortion will be noticed.

EXPERIMENT No. 7

1. Disconnect one of the leads at the "S" meter, to simulate a defective meter. The receiver will operate normally, but the "S" meter will not deflect when the AVC-MANUAL switch is placed in the AVC position.
2. Viewing the receiver from the bottom, locate capacitor C18, which is mounted on the left side. Short the terminal nearest the front panel to ground. This simulates a shorted a-v-c filter capacitor. This will remove the a-v-c and sensitivity-control voltage from the controlled stages.

EXPERIMENT No. 8

1. Disconnect one side of resistor R35 on terminal board E23. This removes both plate and screen volt-

age from the beat-frequency-oscillator tube, V10, and simulates a defective SIGNAL switch, thus causing the receiver to be inoperative for c-w signals.

2. Disconnect the lead on pin 6 of the beat-frequency-oscillator tube, V10, that goes to capacitor C49. This simulates an open capacitor, thus removing the feedback from the oscillator tank circuit. The receiver will not operate on c-w signals.

EXPERIMENT No. 9

1. Connect a jumper across capacitor C25 on terminal board E23. This simulates a shorted coupling capacitor between the 1st audio-amplifier tube, V13, and the a-f driver tube, V14. There will be little or no audio output from the receiver.

2. Disconnect the lead on terminal 3 of the output transformer, T8. This removes the positive supply voltage from V16, one of the push-pull output amplifiers. The receiver will operate, but will have a distorted output at high settings of the AUDIO GAIN control.

EXPERIMENT No. 10

1. Disconnect one of the input leads at the input power plug. This simulates a defective input cable. There will be no power supplied to the power-supply unit.

2. Disconnect the jumper between terminal 1 on choke coil L2 and terminal 2 on choke coil L1. This simulates an open choke coil. No voltage will be supplied to terminals 4, 5, and 6 on terminal strip E1.

EXPERIMENT No. 12

Place any of the troubles described in this supplement in the equipment.

FINAL EXAMINATION

Select any three of the troubles described in this supplement and place them, one at a time, in the equipment.

FIRST AID (Cont.)

The Prone Pressure Method of Artificial Respiration

If Due to Electric Shock

1. **PROTECT YOURSELF** with DRY insulating material.
2. **BREAK THE CIRCUIT** by opening the power switch or pulling the victim free of the live conductor. **DON'T TOUCH THE VICTIM WITH YOUR BARE HANDS UNTIL THE CIRCUIT IS BROKEN.**
3. **SPREAD DRY BLANKET ON THE GROUND,** and roll victim to center of blanket with his arms extended over his head, so that he lies **FACE DOWN** on blanket.
4. **BEND ONE OF THE VICTIM'S ARMS** at the

elbow and rest victim's cheek on the back of his hand.

5. **REMOVE FALSE TEETH,** gum, candy, tobacco, food, etc., from victim's mouth.
6. **LOOSEN ALL TIGHT CLOTHING,** as belts or collars.
7. **COVER VICTIM LOOSELY** by wrapping the ends of the blanket around him.
8. **STRADDLE VICTIM** across thighs.
9. **PLACE THE PALMS OF YOUR HANDS ON VICTIM'S BACK** so that the little fingers of each hand just touch the victim's lowest ribs.



(1) Straddle victim across thighs. Place the palms of your hands on the victim's back so that the little fingers of each hand just touch the victim's lowest ribs.



(2) Keep your arms stiff and straight and swing your body forward, allowing your weight to bear down on victim. **DO NOT PUSH OR USE FORCE.**



(3) Swing back at once to relieve pressure, and then continue the rhythmic application of alternate pressure and release.

Blanket is not shown in above drawings for the sake of clarity.

10. **KEEP YOUR ARMS STIFF AND STRAIGHT** and swing your body forward, allowing your weight to bear down on the victim.
11. **DO NOT PUSH OR USE FORCE.**
12. **SWING BACK AT ONCE TO RELIEVE PRESSURE.**
13. **REPEAT** Step 10.
14. **REPEAT** Step 12.
15. **CONTINUE** as above, maintaining a steady rhythm until victim regains consciousness or is pronounced dead by a doctor.
16. **CONTINUE ARTIFICIAL RESPIRATION** even after victim begins to breathe, and until he becomes conscious.
17. **IF BREATHING STOPS AGAIN,** continue artificial respiration at once.
18. **DO NOT GIVE UP HOPE** of reviving the victim. Four hours or more of continuous application of artificial respiration may be required before consciousness returns.

19. **NEVER TRY TO FORCE LIQUIDS** down an unconscious person's throat. He will drown.
20. **ALWAYS WAIT UNTIL CONSCIOUSNESS RETURNS** before administering liquid stimulants.
21. **RECOMMENDED STIMULANTS ARE:** Hot, black coffee. Strong, hot tea. Aromatic spirits of ammonia, one teaspoonful to a glass of water.
22. **GIVE ONLY ONE STIMULANT,** which should be sipped slowly.
23. **ALCOHOLIC DRINKS** are not recommended, unless absolutely nothing else is available.
24. When **VICTIM HAS RETURNED TO CONSCIOUSNESS,** allow him to lie quietly where he is for at least one hour, taking care that he is well covered and free from worry.
25. **IF POSSIBLE, CARRY, OR HAVE HIM CARRIED TO A DOCTOR.**

LESSON PLAN No. 3 (Cont.)

- k. A-f driver.
- 1. A-f output.
- 5. Locate the functional circuits by using figure 9.
- 6. Discuss the purpose of each of the test points, as follows:
 - a.  —checks entire receiver.
 - b.  —checks audio-frequency section.
 - c.  —checks i-f section.
 - d.  —checks h-f oscillator.
 - e.  —checks r-f section.
 - f.  —and  —check beat-frequency oscillator and noise limiter, respectively.
 - g.  —checks high-voltage and "C"-bias rectifiers.
 - h.  —checks "C"-bias rectifier.

- i.  —checks high-voltage rectifier.
- 7. Review safety precautions and first aid.

CONCLUSIONS

The BC-779-B is a superheterodyne type of receiver, employing 16 tubes; it has a number of unique circuits, including a noise limiter, amplified a.v.c., and a crystal filter.

ORAL QUIZ

- 1. What types of signals can be received?
- 2. What is the major function of the r-f section?
- 3. What is the purpose of the 1st detector?
- 4. What is the frequency relationship between the h-f-oscillator frequency and the received signal?
- 5. What test point checks the over-all performance of the receiver?
- 6. What is the purpose of the crystal filter?
- 7. What is the function of the noise limiter?
- 8. What is the function of the a-f driver?
- 9. When is the beat-frequency oscillator used, and what is its function?
- 10. What is the principle of a superheterodyne receiver?

EXPERIMENT No. 2

TIME ALLOTTED: 2 HR.

SUBJECT

Equipment check by use of major and key test points.

OBJECTIVE

To become familiar with the method of checking the major functional sections of the radio receiver and power-supply unit by use of major and key test points.

EQUIPMENT REQUIRED

- 1 Radio Receiver BC-779-B.
- 1 Power-supply unit.
- 1 Interconnecting cable.
- 1 D-c voltmeter (20,000-ohms-per-volt sensitivity).
- 1 R-f signal generator (100 kc.—20 mc.).
- 1 A-f signal generator.

INSTRUCTIONS

Make certain that the power source is disconnected from the power-supply unit. The units are to be interconnected according to the method outlined in the procedure. Be careful in the handling of the test equipment; do not make any measurements except those outlined in the procedure.

PROCEDURE

- 1. Remove the dust cover from the receiver.
- 2. Remove the bottom plate from the receiver as follows:
 - a. Unscrew the four mounting feet located at each corner on the bottom plate.

- b. Unscrew the five remaining screws and remove the bottom plate.
- 3. Connect the receiver to the power-supply unit as follows:
 - a. Remove the sheet-metal cover from terminal strip E4 on the rear of the receiver and from terminal strip E1 on the power-supply unit.
 - b. Unscrew all ten screws on each strip at least three turns.
 - c. Attach one end of the connector cable to each strip. The spade lugs should slip under the screws from the top.
 - d. Tighten all screws securely.
- 4. Set the controls on the receiver as follows:

CONTROL	POSITION
OFF-ON	OFF
CRYSTAL SELECTIVITY	OFF
PHASING CONTROL	Arrow
BAND WIDTH	3
LIMITER	OFF
AVC-MANUAL	AVC
SENSITIVITY	10
BAND SPREAD	100
SIGNAL	MOD
BEAT OSCILLATOR	0
SEND-REC	REC
AUDIO GAIN	6

- 5. Connect the input power cable on the power-supply unit to the a-c receptacle.
 - 6. Turn the OFF-ON Switch to ON.
- Caution: Be careful to avoid any contact with relay terminals E2 while power is on. It is dangerous. Also be careful to avoid contact with pin 6 of terminal strip

E1 on the power-supply unit or terminal strip E4 on the receiver unit.

7. Check the over-all operation of the power-supply unit by measuring the voltage at major test point **1** as follows:

a. Connect the positive lead of the voltmeter (set for the 250-volt range) to terminal 4, and the negative lead to terminal 7 on terminal strip E1 at the rear of the power-supply unit.

b. The voltmeter should read +170 volts.

8. Check the operation of the "C"-bias rectifier unit by measuring the voltage at key test point **A** as follows:

a. Connect the positive lead of the voltmeter (set for the 100-volt scale) to terminal 7 on terminal panel E1, and the negative lead to ground (terminal 3).

b. The meter should read -60 volts.

9. Check the operation of the high-voltage rectifier by measuring the voltage at key test point **B** as follows:

a. Connect the positive lead of the voltmeter (set for the 250-volt range) to terminal 4 on terminal panel E1, and the negative lead to ground.

b. The meter should read +110 volts.

10. Connect a speaker to the two terminals marked SPKR, test points **H** and **I** at the rear of the receiver.

11. Check the over-all operation of the receiver by applying the proper signals to major test point **2** as follows:

a. Connect the output of the signal generator, modulated at some audio frequency, to terminals marked "A" at the rear of the receiver (major test point **2**). Adjust the signal generator to the following frequencies, in sequence, with the attenuator on the signal generator set to the center of its range.

SIG. GEN. FREQ.	BAND SWITCH	MAIN TUNING DIAL
150 kc.	100—200 kc.	150 kc.
300 kc.	200—400 kc.	300 kc.
3.5 mc.	2.5—5.0 mc.	3.5 mc.
7.5 mc.	5—10 mc.	7.5 mc.
15.0 mc.	10—20 mc.	15.0 mc.

b. A loud, clear signal should be heard from the speaker as each signal is applied to the receiver.

12. Check the functioning of the audio-amplifier section by applying an audio signal to key test point **C** as follows:

a. Connect the ground lead of the audio signal generator to the receiver chassis. Connect the output lead through a .1-mf. capacitor to the upper terminal (test point **C**) on the AUDIO GAIN control, located in the bottom of the receiver, behind the AUDIO GAIN control knob. Turn on the audio signal generator and adjust its attenuator for a weak signal.

b. A very loud, clear tone from the speaker should be heard.

13. Check the functioning of the intermediate-frequency amplifier section by applying an intermediate-frequency signal to key test point **D** as follows:

a. Set the AVC-MANUAL switch to the MANUAL position.

b. Connect the ground lead of the r-f signal generator to the receiver chassis. Connect the output lead to test point **D** located at the grid cap of the 1st-detector tube, V3. Turn on the signal generator and adjust the output frequency to 465 kc. Turn on the modulation, and adjust the output of the signal generator for a low output.

c. If the i-f circuits are functioning properly, a loud, clear signal should be heard from the loud-speaker.

14. Check the operation of the h-f oscillator by measuring the voltage developed in the circuit at key test point **E** as follows:

a. Connect the positive lead of the voltmeter (set for the 30-volt range) to the chassis, and the negative lead to test point **E** located at the grid cap of the h-f-oscillator tube, V4.

Note: An isolating choke should be placed in series with the negative lead of the meter to prevent the meter from loading down the oscillator to a point where it will stop oscillating.

b. The voltmeter should read a minimum of -3 volts.

15. To check the functioning of the r-f section, key test point **F** is used; this test point is the same as major test point **2**. If the proper results were obtained in checking test point **2**, the r-f section is assumed to be operating correctly.

16. Check the operation of the a-v-c section by using key test point **G** as follows:

a. Set the AVC-MANUAL switch to AVC.

b. Tune in a station with a strong, modulated signal.

c. The "S" meter, which is designated as test point **G**, should deflect to the right for a meter reading of 1 to 9.

17. Check the beat-frequency oscillator circuit by using key test point **H** as follows:

a. Turn the SIGNAL switch to the CW position.

b. Tune in a strong c-w signal.

c. A tone should be heard from the speaker, which is designated as test point **H**; the pitch of the tone may be adjusted by the BEAT OSCILLATOR control on the front panel.

18. Check the noise-limiter circuit by using key test point **I** as follows:

a. Turn the SIGNAL switch to the MOD position.

b. Tune in a noise-modulated signal (the noise should be of the pulse type such as that produced by an ignition system).

c. Turn the LIMITER switch to ON.

d. There should be a reduction in the audio volume and a noticeable improvement in the signal-to-noise ratio.

19. Reassemble the equipment and disconnect the power-input cable.

CONCLUSIONS

1. What is the function of major test point **2**?

2. What type of signal is introduced into key test point **D**?

3. In what circuit is key test point **H** located?
4. How is key test point **I** employed to check the noise-limiter circuit?
5. Where is key test point **G** located?
6. What test point is used to check the operation of the local oscillator?
7. What type of signal is introduced at key test

point **C** ?

8. What is the indication of normal h-f-oscillator operation?
9. What test point checks the over-all operation of the power supply?
10. In which unit are key test points **A** and **B** located?

LECTURE No. 4

CIRCUIT ANALYSIS OF R-F AMPLIFIERS

To provide a greater degree of sensitivity and selectivity with a high image ratio, two tuned radio-frequency amplifiers are used ahead of the mixer stage. Both stages operate in the same manner, each stage employing a 6K7 high-gain remote cut-off pentode.

The signals received by the antenna are fed to the antenna terminals marked "AA" at the rear of the receiver. The first section of the band-selector switch, SW1A, selects the proper primary coil of the five different antenna input transformers for the desired frequency band, and connects it to the antenna terminals. Each primary coil of the antenna input transformers is electrostatically shielded from its secondary, to eliminate any capacitive coupling which may introduce extraneous noise signals. The impedance of the antenna input circuit averages approximately 100 ohms throughout the tuning range of the receiver; this value of impedance permits the use of a low-impedance transmission line between the antenna and the receiver, with a minimum of noise pick-up. The second section of the band-selector switch, SW1B, selects the proper tuned secondary of the antenna input transformers, and connects it to the grid of the 1st r-f tube, V1, through the coupling capacitor, C3. The r-f circuits for the 5 to 10-mc. band are shown in figure 12.

The first section of the band-spread capacitor C2A, controlled from the front panel, is connected across the three high-frequency bands. Rotating this capacitor from 100 toward 0 on the BAND SPREAD dial increases the capacitance across these tuned circuits and lowers the operating frequency.

The band-selector switch, SW1A, also connects the first section of the main tuning capacitor, C1A, across the selected tuned secondary. This capacitor section is mechanically coupled to other sections located in the 2nd r-f stage, 1st-detector stage, and oscillator stage, and is controlled from the front panel by the MAIN TUNING control.

The tuned secondaries which are not in use are shorted to ground through the contacts of the band-selector switch, SW1A, to prevent any possible interaction with the operating tuned secondary.

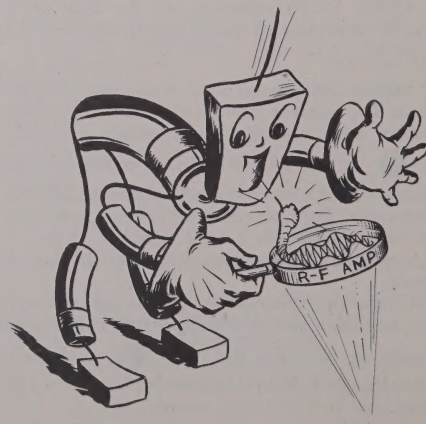
The amplified signal in the plate circuit of the 1st r-f tube is fed to the primary of the 2nd r-f transformer, which is selected by the third section of the band switch, SW1C. The induced signal in the tuned secondary of the 2nd r-f transformer is applied to the grid of the 2nd r-f amplifier tube, V2, through the coupling capacitor, C7. The second section of the band-spread capacitor, C2B, is used across the three highest frequency bands, and is mechanically coupled to the

1st section, C2A. The second section of the main tuning condenser, C1B, is used for tuning all five tuned secondaries.

The amplified signal in the plate of the 2nd r-f stage is fed to the signal grid (grid cap) of the 1st-detector tube, V3, through the untuned primary and tuned secondary of the 1st-detector grid-input transformer, selected by the fourth section of the band-selector switch, SW1D. The third section of the band-spread capacitor, C2C, is used to tune the three highest frequency tuned secondaries as previously described. The third section of the MAIN TUNING condenser, C1C, is used to tune the selected secondary on all bands.

The plate voltage of 250 volts is obtained from terminal 5 on terminal strip E4 through the contacts of the SEND-REC switch, which is shown in the REC position. This voltage is applied to the plates of the tubes through individual decoupling networks, which prevent the r-f signal from being coupled to the power supply. The decoupling network in the plate circuit of the 1st r-f tube consists of R4 and C6; the decoupling network in the plate circuit of the 2nd r-f tube consists of R8 and C10.

The cathodes and suppressor grids of both tubes are connected directly to ground. A negative control bias to control the sensitivity and amplification of each stage is obtained from the a-v-c and sensitivity-control circuit. This voltage is applied to the grid of the 1st r-f tube, V1, through grid-leak resistor R1 and the decoupling network R2 and C4 which is designed to



prevent any r-f energy from entering the a-v-c supply. The negative control bias is applied to the 2nd r-f tube, V2, through grid-leak resistor R5 and the decoupling network, R6 and C8.

A positive 100 volts from terminal 4 on terminal strip E4 is applied to the screen grid of the 1st r-f stage through dropping resistor R3, and to the screen grid of the 2nd r-f stage through dropping resistor R7. To prevent any degeneration in the stage or any possible regenerative feed-back which may cause self-oscillation, the screen grids are by-passed to ground by C5 in the 1st r-f stage, and C9 in the 2nd r-f stage.

To maintain the accuracy of tuning, the tuned secondary for each frequency band in the antenna input transformer, 2nd r-f transformer and 1st-detector-grid-input transformer is adjustable both capacitively and inductively.

To check the operation of the 1st and 2nd r-f stages, test points F_2 and F_3 are used. See figure 12. To check the 2nd r-f stage the rest of the receiver must be functioning correctly. If a modulated signal is applied to test point F_2 , a loud, clear tone heard in the loud-speaker indicates that the 2nd r-f stage is functioning properly. If the signal is then applied to the 1st r-f stage at test point F_3 , a loud, clear tone heard in the loud-speaker indicates that this stage is functioning properly.

LESSON PLAN No. 4

TIME ALLOTTED: $\frac{3}{4}$ HR.

SUBJECT

Circuit analysis of r-f amplifiers.

OBJECTIVE

To provide an understanding of the function and theory of operation of each circuit in the r-f amplifier circuit.

INTRODUCTION

Two stages of r-f preselection are used in the receiver to provide a maximum of selectivity and sensitivity, thus producing a higher image and signal-to-noise ratios.

SUBJECT MATERIAL

1. Explain the over-all purpose of r-f amplifier circuit.
2. Draw the antenna circuit and 1st r-f stage on the blackboard.
3. Explain the operation of the balanced-type input circuit.

4. Explain the operation of the first section of the band switch, SW1A, in selecting the primary of the antenna input transformer.

5. Explain the operation of the second section of the band switch SW1B in selecting the 1st r-f grid input tuned circuit.

6. Explain the band-spread action of the first section of capacitor C2A.

7. Explain the operation of the 1st r-f stage, V1.

8. Explain the action of the third section of the band switch, SW1C, and the function of the 2nd r-f transformer.

9. Draw the 2nd r-f stage, including the 1st-detector grid-input transformer.

10. Explain the operation of the 2nd r-f stage.

11. Explain the action of the fourth section of the band switch, SW1D, in selecting the proper 1st-detector grid-input transformer.

12. Explain the plate-voltage circuits of both stages.

13. Explain the grid biasing and a-v-c circuits of both stages.

14. Explain the screen circuits of both stages.

15. Explain the alignment adjustments of all the transformers in the r-f amplifier section.

16. Explain the use of the test points.

CONCLUSIONS

The r-f amplifier section of the radio receiver, which consists of two tuned radio-frequency amplifier stages on all of the bands covered by the receiver, provide maximum sensitivity, a high image ratio, and a low noise level. The antenna input circuit is electrostatically shielded from the grid of the first tube. Inductive and capacitive trimming are employed in all signal-frequency circuits.

ORAL QUIZ

1. What are three advantages of having two tuned r-f stages ahead of the mixer?
2. What type tubes are used in the 1st and 2nd r-f stages?
3. What is the impedance of the antenna circuit throughout the tuning range of the receiver?
4. On what bands is the band-spread capacitor used?
5. What type of bias is applied to both r-f amplifier stages?
6. How are the grid circuits of both stages tuned?
7. What is the purpose of the decoupling network in the plate-voltage supply of each stage?
8. What method is used to maintain the accuracy of alignment of the tuned circuits?
9. What is the function of test point F_3 ?
10. What is the function of test point F_2 ?

EXPERIMENT No. 3

TIME ALLOTTED: 2 HR.

SUBJECT

R-f amplifiers.

OBJECTIVE

To become familiar with the trouble-shooting pro-

cedure and the alignment check of the r-f amplifier section.

EQUIPMENT REQUIRED

- 1 Radio Receiver BC-779-B (properly aligned).
- 1 Power-supply unit.
- 1 Interconnecting cable.

- 1 R-f signal generator (100 kc.—20 mc.).
- 1 Multimeter (20,000-ohms-per-volt sensitivity).
- 1 Output meter.
- 1 Headset or loud-speaker.

INSTRUCTIONS

Remove the dust cover and bottom plate from the receiver. Connect the receiver to the power supply unit, and plug the line cord into the a-c receptacle. Turn the OFF-ON switch on the receiver to the ON position and allow the receiver to warm up. Do not make any adjustments other than those outlined in the procedure.

PROCEDURE

1. Connect the output meter (set for the highest range) to the terminals marked SPKR at the rear of the receiver.
2. Connect the headset or loud-speaker to the receiver.
3. Adjust the controls on the receiver as follows:

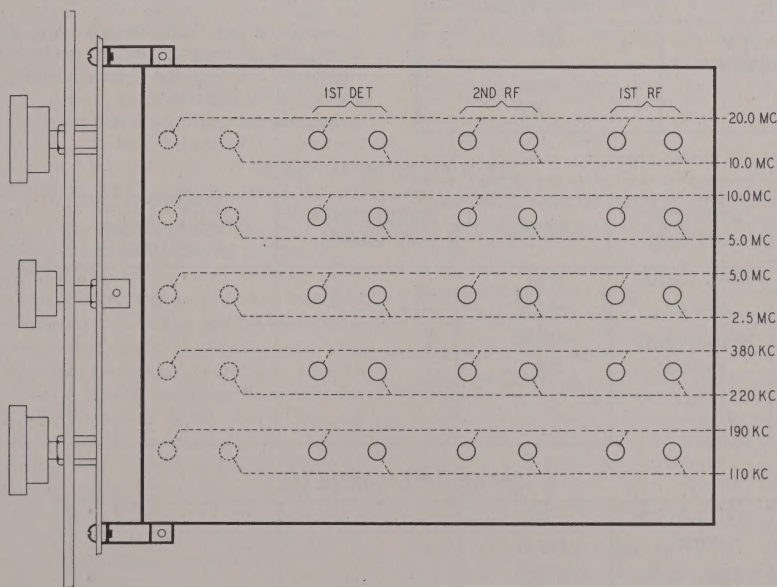
CONTROL	POSITION
SENSITIVITY	10
AUDIO GAIN	10
SIGNAL	MOD
AVC-MANUAL	MANUAL
LIMITER	OFF
CRYSTAL FILTER	OFF
SEND-REC	REC
BAND WIDTH	3
BAND SPREAD	100

4. Check the operation of the 2nd r-f stage by applying the following modulated signals to test point **F₂**, located at grid cap of V2, and adjust the signal-generator attenuator for an output-meter reading of 50 volts and a loud, clear tone in the headset.

SIG. GENERATOR	BAND SWITCH	MAIN TUNING
150 kc.	100—200 kc.	150 kc.
300 kc.	200—400 kc.	300 kc.
3.5 mc.	2.5—5.0 mc.	3.5 mc.
7.5 mc.	5—10 mc.	7.5 mc.
15.0 mc.	10—20 mc.	15.0 mc.

5. Check the operation of the 1st r-f stage by applying a signal at test point **F₃**, located at grid cap of V1, in the manner outlined in step 4. Note that a louder output is heard in the headphones or loud-speaker and that the output-meter reading is greater. Adjust the signal-generator attenuator for an output-meter reading of 50 volts. Note that less signal-generator input is necessary at test point **F₃**, than at test point **F₂** for the same output-meter reading.

6. Check the operation of the antenna circuit by applying a signal through a 100-ohm carbon resistor to test point **F**, located at the antenna terminals, in the same manner as in step 4. A louder output should be heard in the loud-speaker and the output-meter reading should be higher. Adjust the signal-generator attenuator for an output-meter reading of 50 volts.



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Figure A.

Note that less signal-generator input is necessary at test point **F₂** than at test point **F₃** for the same output-meter reading.

7. Adjust the SENSITIVITY control to 10.

8. Connect the signal-generator output through a 100-ohm (approximate) noninductive resistor to the antenna terminals at the rear of the receiver.

9. Set the MAIN TUNING dial to 5.0 mc. on the 2.5—5.0-mc. band, and adjust the frequency of the signal generator for maximum deflection of the output meter. Adjust the SENSITIVITY control for a mid-scale reading on the output meter and, at the same time, check the signal with the headphones or loud-speaker to avoid a false adjustment due to overloading and interference.

10. Vary the setting of the trimmer marked 1ST DET. and 5.0 MC.; see figure A. Any adjustment of this trimmer from the original setting should result in a decrease in the output-meter reading. Also vary the trimmers marked 2ND R.F. and 1ST R.F., in the same row. All these trimmers should be returned to their original settings.

11. Set the MAIN TUNING dial to 2.5 mc. and retune the signal generator to 2.5 mc. Check the three inductance adjustments marked 2.5 MC. (see figure A), using the same procedure as in step 6.

12. Repeat steps 10 and 11 for all the remaining bands. It is very important in all these checks that the receiver be accurately tuned to the test signal. The BAND SPREAD control may be used as a vernier in the bands where its operation is effective.

13. After completing steps 10, 11, and 12 disconnect the signal generator and output meter.

14. Set the front-panel controls on the receiver as follows:

CONTROL	POSITION
SENSITIVITY	0
AUDIO GAIN	0
SIGNAL	CW
LIMITER	ON

15. Using the d-c voltmeter on the multimeter, measure the voltages between the tube-socket terminals and chassis. Record the voltage readings in the following chart:

1ST R-F TUBE V1 (6K7)

PIN No.	VOLTAGE	TUBE ELEMENT
1		
2		
3		
4		
5		
6		
7		
8		

2ND R-F TUBE V2 (6K7)

PIN No.	VOLTAGE	TUBE ELEMENT
1		
2		
3		
4		
5		
6		
7		
8		

16. Turn the OFF-ON switch to the OFF position. Using the ohmmeter on the multimeter, measure the resistance between the chassis and the points indicated in the following chart:

Record the readings in the chart.

1ST R-F STAGE V1 (6K7)

PIN No.	OPERATING CONTROL	POSITION	RESISTANCE IN OHMS	CIRCUIT COMPONENTS MEASURED	TUBE ELEMENT
Grid cap	AVC—MAN switch	AVC			
		MAN			
3	SEND—REC switch	SEND			
		REC			
4					
2ND R-F STAGE V2 (6K7)					
Grid cap	AVC—MAN switch	AVC			
		MAN			
3	SEND—REC switch	SEND			
		REC			
4					

17. After completing the preceding portion of the experiment, request the instructor to place a trouble in the r-f section of the receiver. Use the procedure outlined in steps 1 through 7 to localize the trouble to the defective circuit. Use the procedure outlined in steps 14 through 16 to find the defective component.

CONCLUSION

1. For the same output-meter reading why is less signal strength necessary at test point **F** than at test point **F3**?
2. What type of adjustment is provided for the high end of each band in the r-f section?

LECTURE No. 5

CIRCUIT ANALYSIS OF H-F OSCILLATOR AND 1ST DETECTOR

H-F OSCILLATOR

The h-f oscillator (V4), shown in figure 13, is a conventional Hartley circuit, using a 6J7 pentode connected as a triode by attaching the screen and suppressor grids directly to the plate. A positive 250 volts, obtained from terminal 5 on terminal strip E4, is applied to the plate of the tube through resistor R14. The plate circuit is maintained at r-f ground potential through by-pass capacitor C16. There are five oscillator tank circuits, one for each band of frequencies. Each tank circuit, which consists of a tapped coil in parallel with a trimmer capacitor, is connected through its associated series padder capacitor to the fifth section of the band-selector switch, SW1E. The band-selector switch selects the proper tank circuit for each frequency band. The selected tank circuit is connected in parallel with the fourth section of the main tuning capacitor, C1D, to the grid-leak biasing arrangement, consisting of capacitor C15 and resistor R13, in the grid circuit. The fourth section of the main tuning capacitor, C1D, has the same capacitance and plate shape as the three r-f sections to which it is mechanically coupled. The feed-back necessary for oscillation is obtained by connecting the tap on each oscillator tank coil, through the band-selector switch, to the cathode of the tube. The frequency of oscillation on each band is 465 kc. higher than that of the received signal. The fourth section of the band-spread capacitor, C2D, is connected in parallel with the tuned tank circuits on the three high-frequency bands. Since this section of the band-spread capacitor is mechanically coupled to the three r-f sections, varying the BAND SPREAD control on the front panel will shift the oscillator frequency the same number of kilocycles as the frequency of the r-f circuits. The tracking of the oscillator at the high-frequency end of each band is adjusted by trimmer capacitors. The low-frequency end of the 10—20-mc., 5—10-mc., and 2.5—5.0-mc. band is adjusted by varying the inductance of the tank coils; the series padder capacitors in these bands are fixed. The low-frequency adjustments for the 100—200-kc. and 200—

3. What type of adjustment is provided for the low end of each band?

4. Why was the signal generator connected to the antenna through a 100-ohm resistor?

5. What method is used to isolate the trouble in the r-f section to a particular component?

6. If C6 in the plate circuit of the 1st r-f tube were to become shorted, what would be the voltage reading on the plate?

7. What would be heard in the loud-speaker if C3 in the grid circuit of the 1st r-f tube were to become an open circuit?

400-kc. bands are padder condensers C86 and C87, respectively.

The output voltage is taken from the oscillator cathode, and is fed to the injector grid of the 1st detector. This type of coupling reduces oscillator-frequency variation ("pulling"), which otherwise might be caused by interaction with the 1st detector.

When the oscillator is operating correctly, the grid draws current on the positive half cycles and, due to the action of capacitor C15 and resistor R13, a negative d-c voltage is developed across resistor R13. By connecting a voltmeter with a high internal resistance to test point **E**, located at the grid cap, the oscillator operation can be checked. A negative-voltage reading indicates that the circuit is functioning.

1ST DETECTOR

The 1st-detector stage, shown in figure 13, is an electron-coupled-type mixer employing a 6L7 pentagrid mixer tube. A positive 250 volts, obtained from terminal 5 on terminal strip E4, is applied through the closed contacts of the SEND-REC switch (shown in REC position) and individual decoupling networks to the screen grid and plate. The decoupling network for the screen grid is made up of resistor R12 and capacitor C14; the decoupling network of the plate circuit is made up of resistor R15 and capacitor C18A. The suppressor grid is internally connected to the cathode, which is returned directly to ground. A negative 3-volt bias, obtained from the bias-supply voltage divider, is applied through decoupling resistor and capacitor R10 and C12 and grid-leak resistor R9 to the signal grid. The input voltage from the oscillator cathode is coupled to the injector grid (grid no. 3) through coupling condenser C13 and grid-leak resistor R11. The r-f signal from the 2nd r-f amplifier is applied to the signal grid (grid cap) through coupling capacitor C11 and grid resistor R9.

When the receiver is tuned to an incoming signal, the oscillator, V4, generates an r-f voltage exactly 465 kc. higher in frequency than the signal being amplified by the 2nd r-f amplifier. These two r-f voltages are

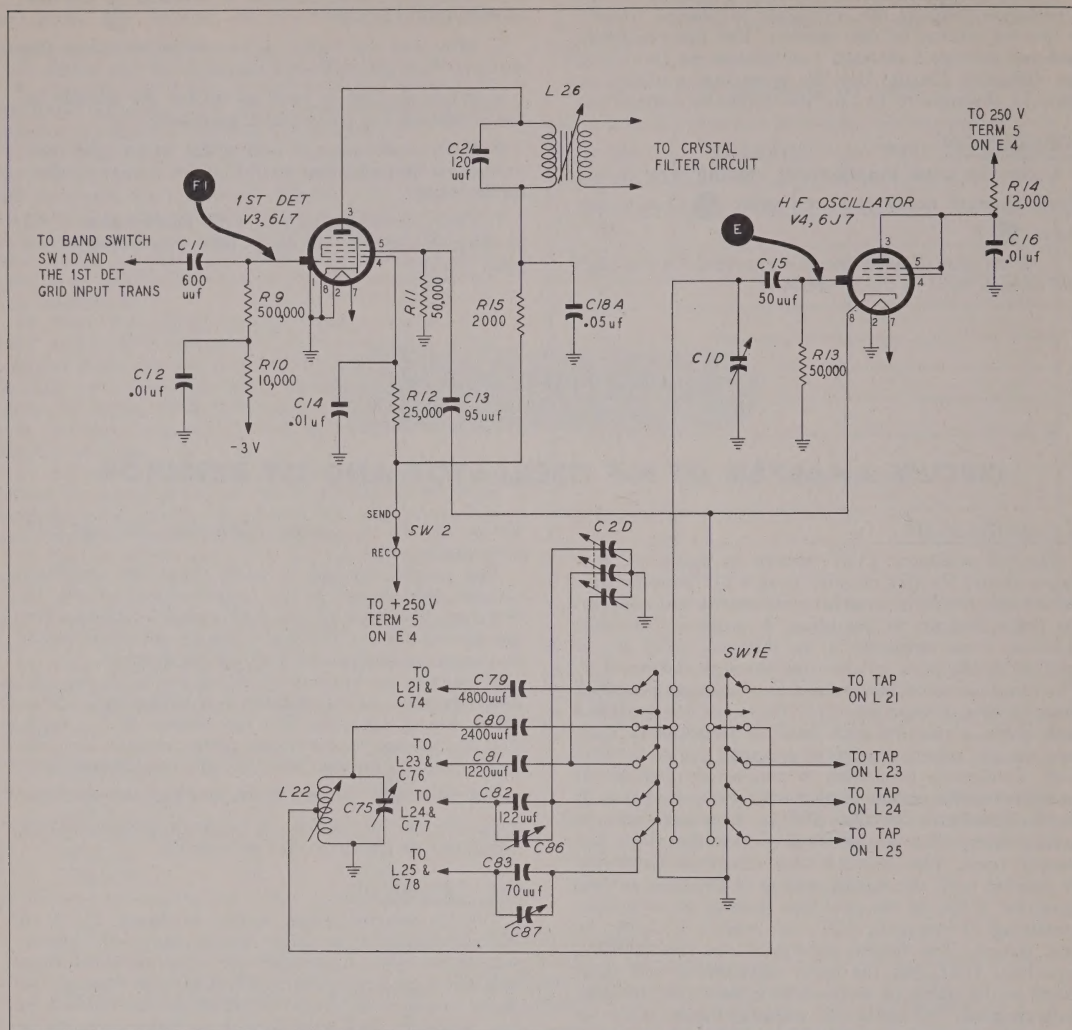


Figure 13. H-F Oscillator and 1st-Detector Circuits

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applied simultaneously to the grids of the 1st detector, and are mixed in the electron stream of the tube. This mixing process results in the generation of a complex r-f voltage waveform in the plate circuit. Among the frequencies present in this waveform are: (1) the incoming signal frequency, (2) the oscillator frequency, (3) the sum of the two frequencies, and (4) the difference between the two frequencies. Since the oscillator frequency is always 465 kc. higher than the incoming signal, the difference or intermediate frequency is always 465 kc. (the frequency of the i-f amplifier). The intermediate frequency is selected for further amplification by means of the tuned circuit,

L26 and C21, in the plate circuit of the 1st detector. This tuned circuit, which is the primary of the 1st i-f transformer, is resonant at 465 kc. and, therefore, allows only the intermediate frequency to be amplified and fed to the secondary of the transformer in the grid circuit of the 1st i-f amplifier. All the other frequencies are by-passed to ground through capacitors C21 and C18A.

Secondary test point (F1), located at the signal grid, is used to check the operation of the 1st detector. When a modulated r-f signal is applied at this point, a loud, clear output should be heard in the loud-speaker.

LESSON PLAN No. 5

TIME ALLOTTED: 1 HR.

SUBJECT

Circuit analysis of h-f oscillator and 1st detector.

OBJECTIVE

To provide an understanding of the function and operation of all the components in the h-f-oscillator and 1st-detector circuits.

INTRODUCTION

The h-f-oscillator and 1st-detector stages convert the received r-f signal, by heterodyne action, into an intermediate frequency.

SUBJECT MATERIAL

1. Locate the 1st-detector and h-f-oscillator circuits on Wall Chart No. 1, and briefly review their over-all function.
2. Locate the 1st-detector and h-f-oscillator circuits on Wall Chart No. 2.
3. Draw the simplified schematic figure 13 upon the blackboard before the lecture.
4. Discuss the type of oscillator circuit used and the manner in which the 6J7 pentode tube is employed.
5. Discuss the d-c operating potentials applied to the tube.
6. Explain the function and construction of the oscillator tank circuits and describe the connections to the band-selector switch.
7. Explain the function of the band-selector switch.
8. Explain the function of the fourth section of the main tuning capacitor, C1D.
9. Explain the action of the fourth section of the band-spread capacitor, C2D.
10. Discuss the provisions for adjusting the tracking of the oscillator on all bands.
11. Explain how feedback is obtained by connecting the cathode to the tank coil.
12. Explain the output circuit of the oscillator.

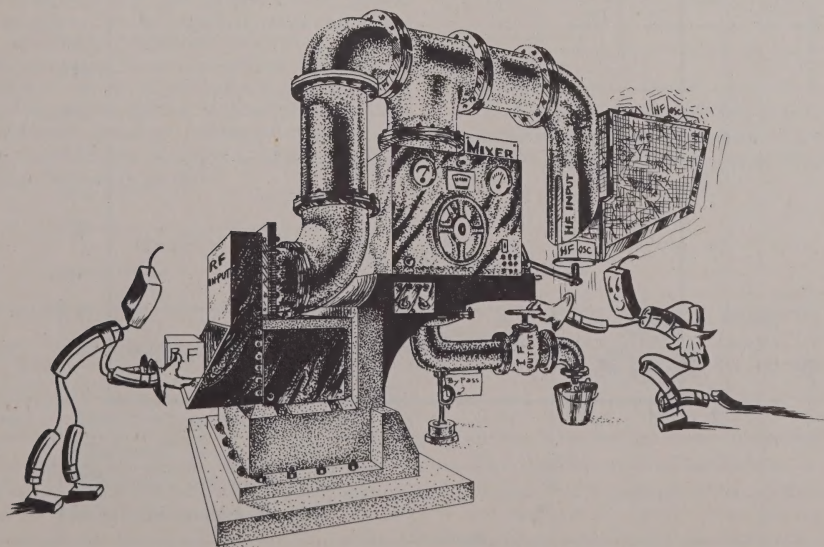
13. Discuss the function and use of test point **E**.
14. Discuss the type of 1st-detector circuit used.
15. Explain the plate, screen, and bias-voltage circuits of the 1st detector.
16. Explain the frequency relationship of the signals fed to the signal and injector grids.
17. Explain the mixing process that occurs in the electron stream of the 1st detector.
18. Describe the output circuit and explain how it selects only the intermediate frequency.
19. Discuss the function and use of test point **F1**.

CONCLUSIONS

Two separate tubes are used in the h-f oscillator and 1st-detector stages. This improves the stability of the receiver and prevents "pulling" of the h-f oscillator. The h-f oscillator operates at a frequency 465 kc. above that of the incoming signal on all bands. The 1st detector mixes the incoming signal with that of the h-f oscillator, and provides the 465-kc. intermediate frequency for the i-f amplifier section.

ORAL QUIZ

1. What type of h-f oscillator circuit is used?
2. What is the function of the fifth section of the band-selector switch, SW1E?
3. On what bands are fixed, series paddler condensers used?
4. How is feed-back obtained?
5. Why is the band-spread capacitor employed in the oscillator?
6. Why is the output voltage taken from the oscillator cathode?
7. What frequencies are present in the plate circuit of the 1st detector?
8. How is the 465-kc. intermediate frequency selected in the plate circuit of the 1st detector?
9. What type of tube is employed as the 1st detector?
10. How is the oscillator coupled to the injector grid of the 1st detector?



EXPERIMENT No. 4

TIME ALLOTTED: 1½ HR.

SUBJECT

1st detector and h-f oscillator.

OBJECTIVE

To become familiar with the trouble-shooting procedure and alignment adjustments for the 1st-detector and h-f oscillator circuits.

EQUIPMENT REQUIRED

- 1 Radio Receiver BC-779-B (properly aligned).
- 1 Power-Supply unit.
- 1 Interconnecting cable.
- 1 R-f signal generator (100 kc.—20 mc.).
- 1 Multimeter: (20,000-ohms-per-volt sensitivity; 50, 250, and 500-volt ranges).
- 1 Headset or loud-speaker.

INSTRUCTIONS

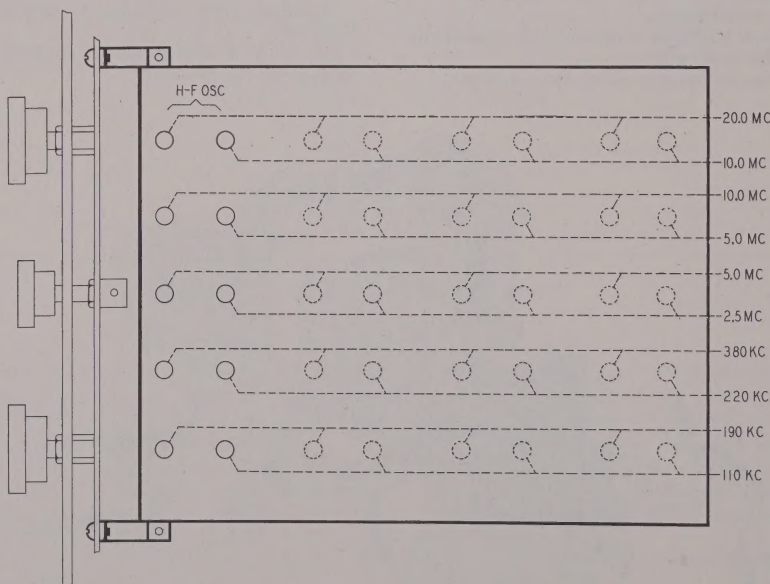
Remove the dust cover and bottom plate from the receiver. Connect the receiver to the power-supply unit and plug the line cord in the a-c receptacle. Turn the OFF-ON switch ON. Allow the receiver to warm up. Do not make any adjustments other than those outlined in the procedure.

PROCEDURE

1. Adjust the front-panel controls as follows:

CONTROL	POSITION
CRYSTAL SELECTIVITY	OFF
PHASING	ARROW
BAND WIDTH	3
LIMITER	OFF
AVC-MANUAL	AVC
SENSITIVITY	10
BAND SPREAD	100
SIGNAL	MOD
BEAT OSCILLATOR	0
SEND-REC	REC
AUDIO GAIN	6

2. Check the operation of h-f oscillator as follows:
 - a. Connect the positive lead of the multimeter (50-volt, d-c range to the chassis; connect the negative lead through an r-f isolating choke or resistor (100,000 ohms or greater) to test point **E**, located at the grid cap of the h-f oscillator tube.
 - b. Tune through the entire tuning range on all bands.
 - c. A negative voltage of approximately 20 volts indicates that the oscillator is operating correctly.
3. Check the operation of the 1st detector, V3, as follows:
 - a. Connect the output of the r-f signal generator to test point **F1**, located at the grid cap of V3.



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Figure A.

b. Turn the modulation on and adjust the r-f signal generator and MAIN TUNING control to the following frequencies. Adjust the signal-generator attenuator for a weak output.

SIGNAL GENERATOR	CONTROL SWITCH	BAND MAIN TUNING
150 kc.	100—200 kc.	150 kc.
300 kc.	200—400 kc.	300 kc.
3.5 mc.	2.5—5.0 mc.	3.5 mc.
7.5 mc.	5.0—10 mc.	7.5 mc.
15.0 mc.	10—20 mc.	15.0 mc.

c. A loud, clear signal should be heard from the speaker on all five bands.

4. The accuracy of the MAIN TUNING dial is determined primarily by the accuracy of the h-f oscillator. Check the accuracy of the h-f oscillator as follows:

a. Adjust the controls on the front panel as follows:

CONTROL	POSITION
SIGNAL	CW
BEAT OSCILLATOR	0
AUDIO GAIN	10
AVC-MANUAL	MANUAL
BAND WIDTH	16

b. Connect a headset or loud-speaker to the receiver.

c. Connect the signal generator to the antenna terminals.

d. Starting with the 100—200-kc. band adjust the signal generator for the low-frequency end of the band. Turn the MAIN TUNING control towards 100 kc. on the main tuning dial until a zero beat is heard in the headphones. The zero beat should be obtained when the MAIN TUNING dial reads exactly 100 kc. Adjust the signal generator for the high-frequency end of the band and repeat this procedure. NOTE: A very accurate signal generator should be used in these checks. If the accuracy of the signal generator is undetermined, the output frequencies should be checked against an accurate frequency meter or frequency standard.

e. Using the procedure outlined in step d, check all the remaining frequency bands.

5. Disconnect the signal generator and adjust the front-panel controls as follows:

CONTROL	POSITION
SENSITIVITY	0
AUDIO GAIN	0
SIGNAL	CW
AVC-MANUAL	MANUAL
SEND-REC	REC
LIMITER	ON

6. Turn the receiver upside down. Using the d-c voltmeter, measure the voltages between the 1st-detector and h-f-oscillator tube-socket terminals and chassis. Record the readings in the following chart.

1ST-DETECTOR TUBE V3 (6L7)

PIN NO.	VOLTAGE	FUNCTION
1		
2		
3		
4		
5		
6		
7		
8		

H-F OSCILLATOR TUBE V4 (6J7)

PIN NO.	VOLTAGE	FUNCTION
1		
2		
3		
4		
5		
6		
7		
8		

7. Turn the power OFF-ON switch OFF. Using the ohmmeter, measure the resistances between the chassis and the socket terminals indicated in the following chart.

1ST-DETECTOR TUBE V3 (6L7)

PIN NO.	OPERATING CONTROL	RESISTANCE IN OHMS	CIRCUIT COMPONENTS MEASURED	TUBE ELEMENT
Grid cap	SEND-REC switch to SEND			
3	SEND-REC switch to REC			
4	SEND-REC switch to SEND			
5	SEND-REC switch to REC			

PIN NO.	OPERATING CONTROL	RESISTANCE IN OHMS	CIRCUIT COMPONENTS MEASURED	TUBE ELEMENT
Grid cap				
3,4,5.				
8				

8. After completing this portion of the experiment, request the instructor to put a trouble into the 1st-detector and h-f-oscillator circuits. Use the procedure outlined in steps 1 through 3 to check the over-all operation of these circuits. Use the procedure given in steps 6 and 7 to locate the faulty component.

CONCLUSIONS

1. Why does the presence of a d-c voltage at test

point **E** indicate that the oscillator is operating correctly?

2. Where is test point **F1** located?

3. What factor primarily determines the accuracy of the main tuning dial?

4. What device can be used to check the accuracy of the signal generator?

5. If capacitor C13 were to become defective (open circuit), what would be the effect on the output of the receiver?

LECTURE No. 6

CIRCUIT ANALYSIS OF CRYSTAL FILTER

A crystal-filter circuit is incorporated in the receiver to provide a high degree of i-f selectivity; it may be switched into the i-f circuit and set for various degrees of selectivity or it may be disabled, as desired. The simplified schematic diagram of the circuit is shown in figure 14.

The quartz crystal, Y1, is resonant at 465 kc. The equivalent electrical circuit of the crystal is a series-tuned circuit, having a very high Q (in the order of 10,000) and a high L/C ratio, shunted by another capacitance which is much larger than that of the series-tuned circuit. This shunt capacitance consists of the capacitance between the crystal electrodes within the crystal holder, and the distributed capacitance of the associated wiring. Crystal Y1, considered as a unit, is series-resonant at 465 kc., and is parallel-resonant at a slightly higher frequency. (The frequency of parallel resonance is but a fraction of kilocycle greater than 465 kc. due to the high Q and the high L/C ratio of the series-tuned-circuit branch of the equivalent circuit of the crystal.)

The output i-f signal from the 1st-detector tube, V3, is developed across the primary winding of L26, and is transferred to the crystal-filter circuit through the secondary winding. The primary winding of L26 and capacitor C27, which is in parallel with it, is tuned, by means of the powdered iron core, to resonate at 465 kc. The secondary winding of the transformer is not tuned; therefore, a low-impedance source of i-f signal voltage is provided for the excitation of the crystal filter.

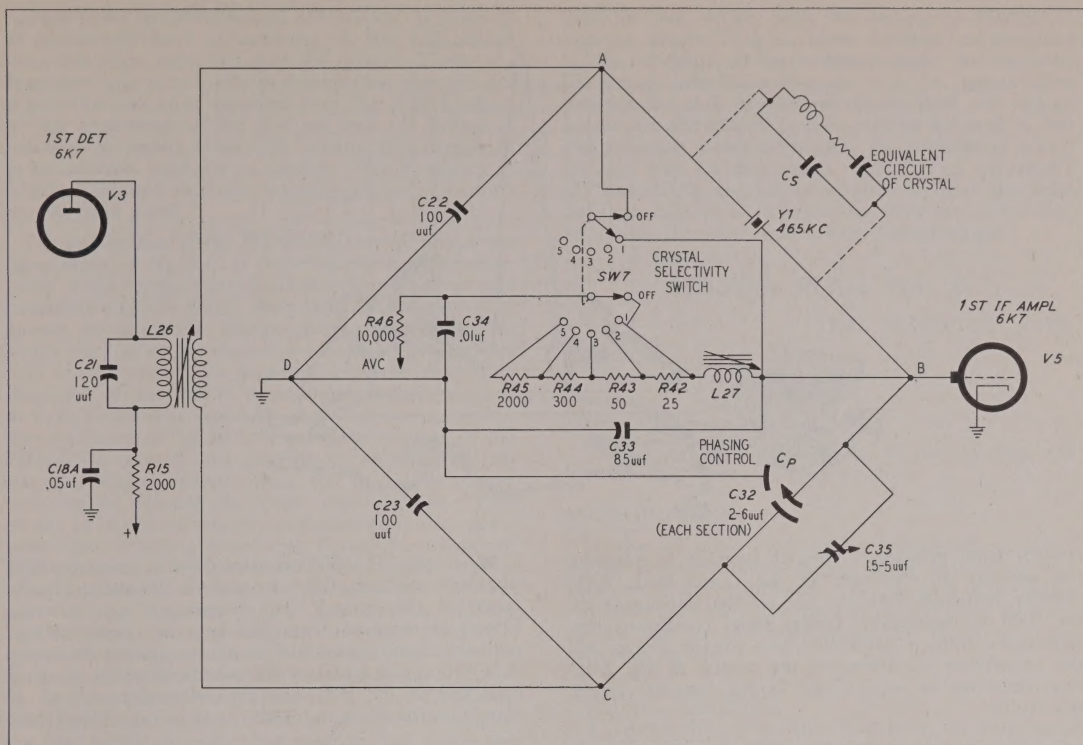
The various circuit elements which compose the crystal filter are connected in a bridge circuit as shown in figure 14. The four basic junction points of the

bridge are labelled A, B, C, and D for easy reference. The input voltage is applied between points A and C, and the output voltage appears across points B and D. The four branch legs are A-D, C-D, A-B, and C-B. The output load impedance is leg B-D.

Legs A-D and C-D are made up of capacitors C22 and C23, respectively, which are of equal capacitance and, thus, serve to balance the secondary voltage of L26 with respect to ground (point D). Leg A-B contains crystal Y1. Leg C-B is made up of trimmer capacitor C35 and one section of capacitor C32.

CAPACITOR C32 IS OF THE OPPOSED-STATOR VARIABLE AIR-DIELECTRIC TYPE. IT IS CONSTRUCTED SO THAT THE SUM OF THE TWO CAPACITANCES BETWEEN THE ROTOR AND THE TWO STATORS IS CONSTANT AS THE ANGULAR POSITION OF THE ROTOR IS VARIED. THAT IS, WHEN THE POSITION OF THE ROTOR IS CHANGED SO THAT THE CAPACITANCE BETWEEN THE ROTOR AND ONE STATOR INCREASES A CERTAIN AMOUNT, THE CAPACITANCE BETWEEN THE ROTOR AND THE OTHER STATOR DECREASES THE SAME AMOUNT.

Leg B-D, the output load impedance, is a parallel-tuned circuit which consists essentially of inductor L27 and the parallel combination of capacitors C33, C32, and C35. From the standpoint of this tuned circuit, capacitors C34 and C23 are r-f by-passes, since the reactance of each at 465 kc. is much less than that of the branch elements to which each is connected in series. This tuned circuit is normally adjusted, with the CRYSTAL SELECTIVITY switch



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Figure 14. Crystal-Filter Circuit

in positions 1 through 5, to resonate at 465 kc. so that a resistive load exists across the output terminals (points B and D) of the bridge. Resistors R42, R43, R44, and R45 are switched into or out of the inductive branch by one section of switch SW7, to provide control of the Q of the circuit and, hence, vary the resistive load presented to the output terminals of the bridge at frequencies near 465 kc. That is, as the resistance in the circuit is *increased*, the load impedance is *decreased*. The converse is true when the resistance is switched out of the circuit. The control grid of the 1st i-f amplifier tube, V5, is connected to point B and the cathode is connected to ground; therefore, the output voltage of the bridge is fed to the 1st i-f amplifier stage.

The two sections of switch SW7 are ganged mechanically and are operated by the CRYSTAL SELECTIVITY knob on the front panel. This control has six positions, OFF, 1, 2, 3, 4, and 5.

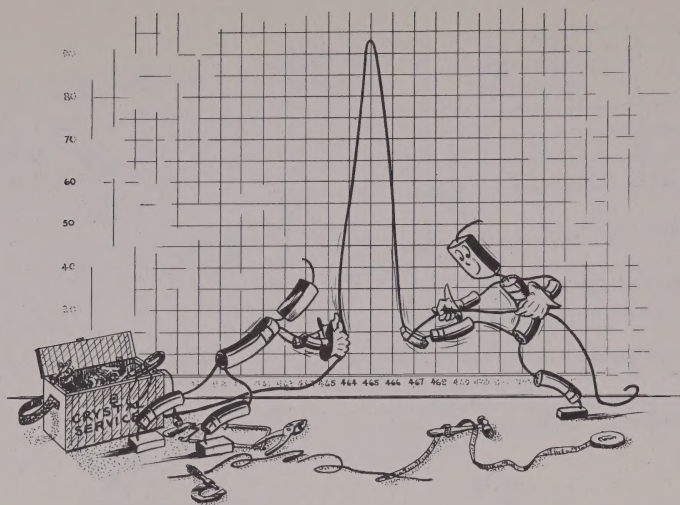
The rotor of capacitor C32 is operated by the PHASING control on the front panel, and is continuously variable from 0 to 10. The midposition is marked with an arrow on the panel.

When the CRYSTAL SELECTIVITY switch is in the OFF position, leg A-B is shorted, and the output voltage of the bridge is equal to one half of the input voltage; for this condition, the selectivity of the overall circuit is nominal.

When the CRYSTAL SELECTIVITY switch is in

any one of the five numbered positions, the short is removed from leg A-B, placing the crystal into the circuit. At frequencies considerably removed from 465 kc., the crystal impedance is extremely high. The effective impedance of leg A-B at these frequencies is equal to the impedance of the shunt capacitance of the crystal holder, Cs. When the PHASING control is set to the arrow, the capacitance of leg B-C is equal to the shunt capacitance of leg A-B. This condition is obtained by the proper adjustment of trimmer capacitor C35. Under these conditions the bridge is essentially balanced, and the transfer of undesired signals at frequencies considerably removed from 465 kc., through the shunt capacitance of the crystal, is minimized.

The amount of voltage across the load, B-D, is determined by the relative impedances of leg A-B and the load, B-D. Maximum voltage across the load will occur at 465 kc. where the impedance of the load is great and the crystal in leg A-B exhibits the very low impedance of a series-resonant circuit. As the frequency deviates from 465 kc. the voltage across the load decreases, due to a sharp increase in the impedance of leg A-B while the impedance of the load, B-D, remains relatively constant. It is clear, therefore, that the ratio of the impedances of leg A-B and the load, B-D, determines the selectivity of the crystal-filter circuit. Varying the CRYSTAL SELECTIVITY



control from position 1 toward position 5 increases the amount of resistance in the tuned load, B-D, thereby reducing both the Q and the impedance of the load at resonance. Under these conditions the impedance ratio is controlled to a greater degree by the impedance variations of the crystal in leg A-B, thus resulting in an increase in the over-all circuit selectivity.

When the PHASING control is set to the arrow, the phasing capacitor, C32, is equal to the shunt capacitance of the crystal. For frequencies one or two kilocycles removed from 465 kc., the combined impedance of the crystal and its shunt capacitance in leg A-B will not be equal to the impedance of the phasing capacitor in leg B-C, and the selectivity will be as shown on the curve in figure 15. When the PHASING

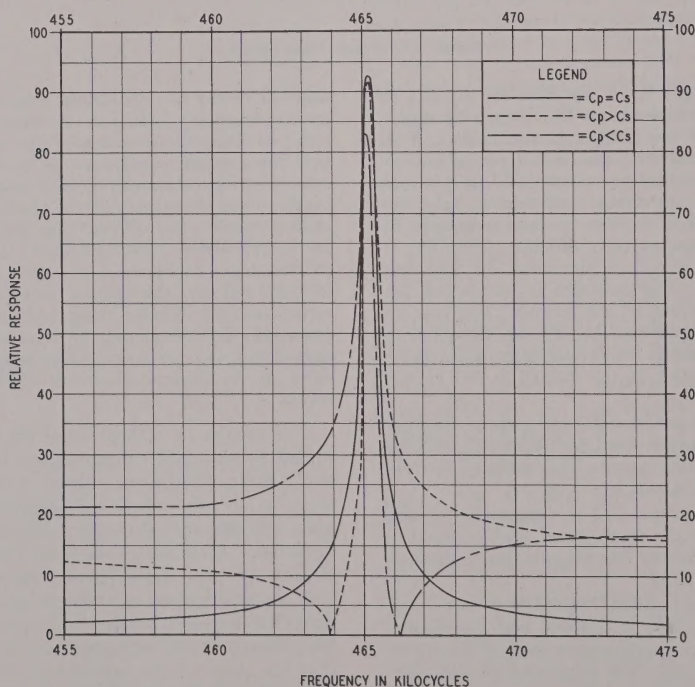


Figure 15. Selectivity Characteristics of Crystal-Filter Circuit

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control is set to either side of the arrow, the phasing capacitor will have either more or less capacitance than the shunt capacitance of the crystal. There is a frequency one or two kilocycles removed from 465 kc. where the combined impedance of leg A-B is equal to the impedance of leg B-C, so that the bridge is balanced at points B and D, causing this frequency to be rejected from the i-f section. The frequency at which maximum rejection occurs is commonly called the *rejection notch*.

For any setting of the PHASING control where the capacitance of leg B-C is less than the shunt capacitance of the crystal, the rejection notch will occur at a frequency slightly higher than 465 kc. The exact frequency at which the bridge will balance is that at which the inductive reactance of the equivalent circuit of the crystal, in parallel with the capacitive reactance of the shunt capacitance, causes leg A-B to have a reactance equal in magnitude to the capacitive reactance of leg B-C. Thus these settings of the PHASING control will give better rejection of frequencies slightly *higher* than 465 kc., with poorer rejection of frequencies *lower* than 465 kc. This results in improved receiver performance under conditions where a strong interfering signal of a frequency slightly lower than that of the desired signal is present. For example, if the receiver is tuned to a 3000-kc. signal and an interfering signal is at 2999 kc., the h-f oscillator will be operating at 3465 kc. Thus two intermediate frequencies will be produced—the desired signal at 465 kc. and the interfering signal at 466 kc. Since the interfering signal is higher in frequency than the desired signal, it can be rejected by setting the PHASING control to the position that makes the capacitance of leg B-C less than the shunt capacitance of the crystal by the proper amount.

For any setting of the PHASING control where the capacitance of leg B-C is greater than the shunt capacitance of the crystal, the rejection notch will occur at a frequency slightly lower than 465 kc. The exact frequency at which the bridge will balance is that at which the capacitive reactance of the equivalent circuit of the crystal, in parallel with the capacitive reactance of the shunt capacitance, causes leg A-B to have a reactance equal in magnitude to the capacitive reactance of leg B-C. Thus these settings of the PHASING control will give better rejection of frequencies slightly *lower* than 465 kc., with poorer rejection of frequencies *higher* than 465 kc. This results in improved receiver performance under conditions where a strong interfering signal of a frequency slightly higher than that of the desired signal is present. For example, if the receiver is tuned to a 3000-kc. signal and the interfering signal is at 3001 kc., the h-f oscillator will be operating at 3465 kc. Thus two intermediate frequencies will be produced—the desired signal of 465 kc. and the interfering signal at 464 kc. Since the interfering signal is lower in frequency than the desired signal, it can be rejected by setting the PHASING control to the position that makes the capacitance of leg B-C greater than the shunt capacitance of the crystal by the proper amount.

In general, the farther the PHASING control pointer is set from the arrow, the closer is the rejection notch to the pass frequency of the crystal-filter circuit.

The proper setting of the BEAT OSCILLATOR con-

trol, in conjunction with the setting of PHASING control, results in even better receiver performance under conditions of severe interference. For example, if strong interfering signals exist on transmission frequencies both higher and lower than the desired signal, the PHASING control may be adjusted so that the rejection notch eliminates the interfering signal on one side of the desired signal, and the BEAT OSCILLATOR control is adjusted so that the beat-oscillator signal is in zero-beat with the interfering signal on the other side of the desired signal.

LESSON PLAN No. 6

TIME ALLOTTED: 1 HR.

SUBJECT

Circuit analysis of crystal filter.

OBJECTIVE

To provide an understanding of the function and operation of the crystal-filter circuit.

INTRODUCTION

In the reception of c-w telegraph signals or radio-telephone communication signals it is imperative that interference be suppressed. The use of a crystal-filter circuit allows only the desired signal to be selected by the receiver and provides for the rejection of interfering signals.

SUBJECT MATERIAL

1. Locate the crystal-filter circuit on the functional block diagram, Wall Chart No. 1.
2. Locate the crystal-filter circuit on the schematic diagram, Wall Chart No. 2.
3. Draw the simplified schematic diagram of the crystal-filter circuit on the blackboard. See figure 14.
4. Discuss the over-all characteristics of the crystal, mentioning the following points:
 - a. The type of crystal and its resonant frequency.
 - b. Q and L/C ratio.
 - c. Shunt capacitance.
 - d. Equivalent circuit and parallel-resonant characteristics.
5. Describe the primary and secondary windings of L26, and the method of transferring the signal from the 1st-detector stage to the crystal-filter circuit.
6. Discuss the components of each leg of the bridge circuit, mentioning the following:
 - a. Input and output junction points.
 - b. Components in each leg.
 - c. Physical construction of capacitor C32.
 - d. Output load circuit.
7. Describe the front-panel operation of the CRYSTAL SELECTIVITY switch.
8. Describe the front-panel operation of the PHASING control.
9. Describe the operation of the crystal-filter circuit when the CRYSTAL SELECTIVITY switch is in the OFF position.
10. Describe the operation of the crystal-filter circuit in any of the five numbered positions, mentioning the following:
 - a. Operation at frequencies considerably removed from 465 kc.

b. Output voltage across load at series-resonant frequency of crystal.

c. Output voltage across load as frequency deviates from series resonance, and effect of increasing the resistance in the tuned load circuit.

11. Using figure 15 explain the action of the crystal-filter circuit at frequencies one or two kilocycles removed from 465 kc. when:

a. PHASING control is set to the arrow.

b. PHASING control is set to a position which makes the capacitance of leg B-C less than the shunt capacitance of the crystal.

c. PHASING control is set to a position which makes the capacitance of leg B-C greater than the shunt capacitance of the crystal.

12. Explain the action of the PHASING control in conjunction with the BEAT OSCILLATOR control to increase the receiver performance under conditions of severe interference from two signals.

CONCLUSIONS

The crystal filter employs a crystal and a balanced phasing capacitor in a bridge circuit to provide a high degree of selectivity, which is variable in five steps, from relatively low selectivity for phone reception, to knife-edge selectivity for c-w reception. Three CRYSTAL-SELECTIVITY switch positions are for

phone reception and two are for c-w reception.

ORAL QUIZ

1. What type of crystal is used in the crystal-filter circuit?

2. What type of circuit is the crystal equivalent to?

3. Why is the secondary winding of L26, at the input to the bridge circuit, untuned?

4. Does moving the CRYSTAL SELECTIVITY switch from position 1 to position 3 increase or decrease the selectivity?

5. Does increasing the resistance in the load circuit increase or decrease the selectivity?

6. What is meant by the rejection notch?

7. How is the position of the rejection notch affected when the capacitance of the PHASING control is made greater than the shunt capacitance of the crystal?

8. How is the position of the rejection notch affected when the capacitance of the PHASING control is made less than the shunt capacitance of the crystal?

9. Where is the rejection notch located when the PHASING control is set to the arrow position?

10. How is the BEAT OSCILLATOR control used in conjunction with the PHASING control?

LECTURE No. 7

CIRCUIT ANALYSIS OF I-F AMPLIFIERS

To provide a greater degree of selectivity with the required gain, three stages of intermediate-frequency amplification are used in the receiver, as shown in the simplified schematic diagram in figure 16. Special transformers are employed to maintain a high degree of stability, and to make it possible to vary the band width of the i-f section. The band width is controlled by a cam arrangement which varies the coupling in two of the i-f transformers, and is variable from 16 kc. down to 3 kc. with the crystal filter out of the circuit. With the crystal filter in the circuit, the bandwidth is variable down to less than 100 cycles.

The intermediate-frequency signal from the crystal-filter load circuit (L27 and C33) is applied to the control grid of the 1st i-f amplifier, V5. This stage amplifies the signal, which is then coupled to the 2nd i-f amplifier stage. The 1st i-f amplifier tube is a 6K7 remote-cut-off pentode. The suppressor grid and cathode are returned directly to ground. Bias for this stage is obtained from the a-v-c and sensitivity-control circuit and applied to the grid through the decoupling network, R46 and C34. A positive 110 volts from terminal 4 on terminal strip E4 is applied to the screen grid through the screen-grid voltage-dropping resistor, R16; capacitor C18 by-passes the signal voltage from the screen grid to ground. The plate voltage is obtained from the positive 250-volt supply at terminal 5 on terminal strip E4, and is applied

through the decoupling network, R17 and C19, and the primary of the second i-f transformer, T2, to the plate of the tube. The amplified signal in the plate circuit is coupled through the tuned primary, L28 and C36, of the 2nd i-f transformer, T2, to the tuned secondary, L29 and C37, located in the grid circuit of the 2nd-i-f amplifier tube. The secondary coil of transformer T2 is fixed in position, while the primary coil is mounted on slide rods, permitting it to be moved back and forth with respect to the secondary by means of the BAND WIDTH control on the front panel. When the coils are moved apart as far as possible, the coupling is at its lowest value, and the selectivity of the tuned circuits (L28 and C36, and L29 and C37) is maximum, providing minimum band width. When the coils are moved as close together as possible, the selectivity of the tuned circuits is minimum, providing maximum band width.

The 2nd i-f amplifier, V6, amplifies the signal obtained from the 1st i-f amplifier and feeds it through the 3rd i-f transformer, T3, to the 3rd i-f amplifier stage. The grid of the 2nd i-f amplifier is connected to a tap on secondary coil L29, which is located approximately one tenth of the total turns from the low-potential end of the coil. Connecting the grid to this tap prevents any variations in the grid input capacitance and conductance from having any effect on the tuning. The 2nd i-f amplifier employs a 6SK7 remote-

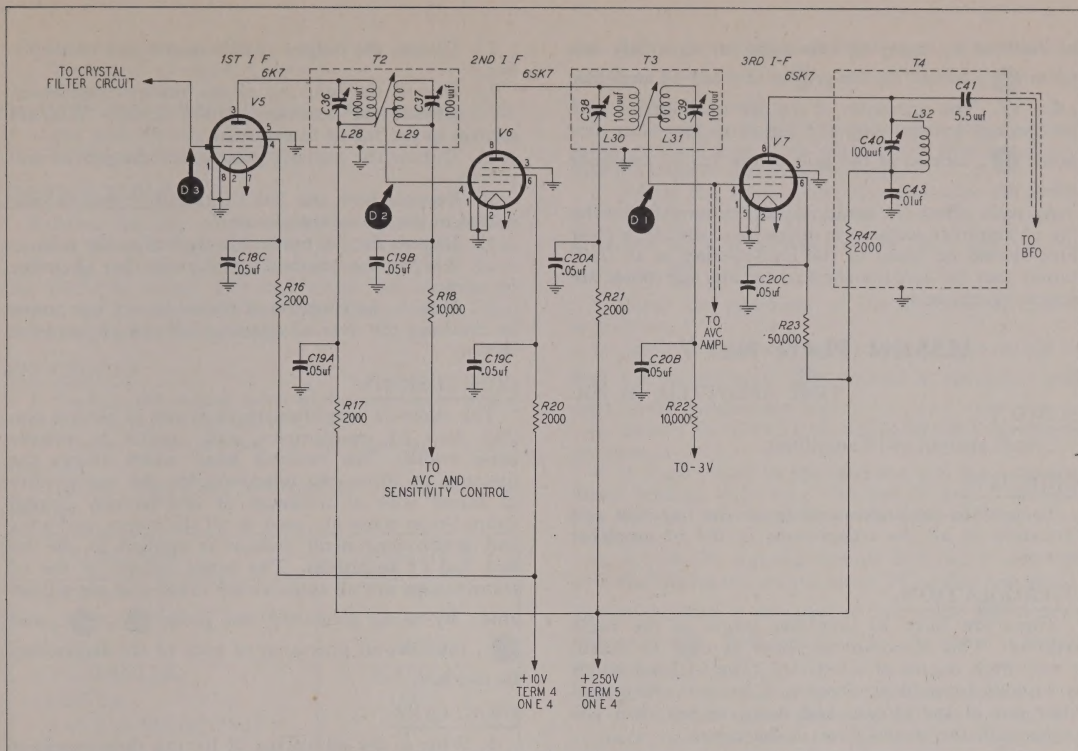


Figure 16. I-F Amplifier Circuits

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cut-off pentode. The cathode and suppressor grid are returned directly to ground. The a-v-c and sensitivity-control voltage is applied as bias to the grid through the decoupling network consisting of resistor R18 and capacitor C19B. A positive 110 volts is applied to the screen grid through resistor R20; capacitor C19C bypasses any variations in the screen-grid voltage to ground. The plate of the tube is connected to the positive 250-volt supply through the primary coil of the 3rd i-f transformer and the decoupling network consisting of resistor R21 and capacitor C20A. The amplified i-f signal from the 2nd i-f amplifier is fed through the primary tuned circuit, L30 and C38, of the 3rd i-f transformer to the secondary tuned circuit, L31 and C39, to the grid of the 3rd i-f amplifier tube, V7. The 3rd i-f transformer is constructed exactly like the 2nd i-f transformer and functions in the same manner. The BAND WIDTH control, which varies the band width of the 2nd i-f transformer is mechanically coupled to the 3rd i-f transformer to vary its band width.

The 3rd i-f amplifier, V7, is the final amplifier in the i-f section. This stage amplifies the i-f signal from the 2nd i-f amplifier and feeds it to the 2nd-detector stage.

The grid of the third i-f amplifier tube is connected to the secondary coil, L31, of the 3rd i-f transformer, which is tapped in the same manner as the secondary coil, L29, in the 2nd i-f transformer. The i-f signal at

this point is also fed through a shielded lead to the grid of the a-v-c amplifier tube.

The 3rd i-f amplifier is a 6SK7 remote-cut-off pentode. The suppressor grid and cathode are returned directly to ground. A 3-volt negative bias is applied to the grid from the "C"-bias voltage divider through the decoupling network consisting of resistor R22 and capacitor C20B, and the secondary coil L31 of the 3rd i-f transformer. The positive 250-volt supply is connected to the screen grid through resistor R23, and to the plate through the decoupling network consisting of resistor R47 and C43, and the primary coil of the 4th i-f transformer, T4. Capacitor C20C places the screen grid at r-f ground potential. The amplified output in the plate circuit of the 3rd i-f amplifier is transferred by the tuned primary and untuned secondary of the 4th i-f transformer to the 2nd detector.

In the 2nd and 3rd i-f transformers, the primary and secondary tuned circuits are adjusted to 465 kc. by means of the trimmer capacitors located in the transformer shield cans. The tuned primary of the 4th i-f transformer is also adjusted by means of a trimmer capacitor, which is located in the shield can.

The over-all operation of the i-f amplifier section may be checked by applying a modulated signal at the intermediate frequency to secondary test point 03, located at the grid of the 1st i-f amplifier tube, V5. The operation of the 2nd and 3rd i-f amplifiers may

be checked by applying this signal at secondary test point **D2**, located at the grid of the 2nd i-f amplifier tube, V6. The operation of the 3rd i-f amplifier may be checked by applying the signal to secondary test point **D1**, located at the grid of the 3rd i-f amplifier tube, V7.

As each check is made, if the circuits following the i-f amplifier section are operating correctly, a clear tone should be heard in the loud-speaker as an indication that the circuits checked by that test point are operating correctly.

LESSON PLAN No. 7

TIME ALLOTTED: $\frac{3}{4}$ HR.

SUBJECT

Circuit analysis of i-f amplifiers.

OBJECTIVE

To provide an understanding of the function and operation of all the components in the i-f amplifier section.

INTRODUCTION

There are three i-f amplifier stages in the radio receiver. This elaborate amplifier is used to obtain a very high degree of selectivity. The i-f band width is variable from 16 kc. down to 3 kc. with the crystal filter out of the circuit, and down to less than 100 cycles with the crystal filter in the circuit.

SUBJECT MATERIAL

1. Discuss the over-all function and operation of the i-f amplifier section, and locate it on the functional block diagram, Wall Chart No. 1.
2. Locate the i-f amplifier on the schematic diagram, Wall Chart No. 2.
3. Draw figure 16 on the blackboard.
4. Discuss the signal applied to the 1st i-f amplifier, and explain the function of the stage.
5. Discuss the d-c potentials applied to the 1st i-f amplifier.
6. Discuss the output circuit of the 1st i-f amplifier.
7. Discuss the mechanical construction of the 2nd i-f transformer, and explain the function of the BAND-WIDTH control.
8. Give a detailed explanation of the method of varying the band width of the 2nd i-f transformer.
9. Explain the over-all function of the 2nd i-f amplifier.
10. Explain how the 2nd i-f amplifier grid is coupled to the 2nd i-f transformer.
11. Discuss the d-c potentials applied to the tube.

12. Discuss the output circuit of the 2nd i-f amplifier.

13. Discuss the function of the 3rd i-f transformer.

14. Discuss the function of the BAND WIDTH control in the 3rd i-f transformer.

15. Discuss the over-all function of the 3rd i-f amplifier.

16. Explain how the 3rd i-f amplifier grid is connected to the 3rd i-f transformer.

17. Discuss the d-c potentials applied to the tube.

18. Discuss the method of tuning the i-f transformers.

19. Discuss the function of the secondary test points in checking the over-all operation of the i-f amplifier section.

CONCLUSIONS

The three i-f amplifier stages in the i-f section employ four i-f transformers, and provide a variable band width. The variable band width allows the operator to adjust the selectivity for the best quality of sound with a minimum of interference. Super-control-type tubes are used in all the stages, and a-v-c and sensitivity-control voltage is applied to the 1st and 2nd i-f amplifiers. The tuned circuits in the i-f transformers are all capacitively tuned and are adjustable. By using secondary test point **D3**, **D2**, and **D1**, the over-all operation of each of the stages may be checked.

ORAL QUIZ

1. What is the advantage of having three stages of i-f amplification?
2. How is a high degree of stability obtained?
3. What are the maximum and minimum band widths that the i-f section can be adjusted for with the crystal filter out of the circuit?
4. What type of bias is applied to the 1st and 2nd i-f amplifier stages?
5. Is the coupling between the primary and secondary of the 2nd i-f transformer maximum or minimum when the BAND WIDTH control is set for maximum band width?
6. What is the advantage of connecting the grid of the 2nd i-f amplifier to a low-potential point on the secondary coil in the 2nd i-f transformer?
7. To what circuits is the tap on the secondary coil of the 3rd i-f transformer connected?
8. What are the functions of secondary test points **D3**, **D2**, and **D1**?
9. To what frequency are all the tuned circuits adjusted?
10. How is the tuning of the i-f tuned circuits adjusted?

EXPERIMENT No. 5

TIME ALLOTTED: 2 HR.

SUBJECT

Crystal filter and intermediate-frequency-amplifiers.

OBJECTIVE

To become familiar with the trouble-shooting and

alignment procedure for the crystal-filter circuit and intermediate-frequency-amplifier section.

EQUIPMENT REQUIRED

- 1 Radio Receiver BC-779-B (properly aligned).
- 1 Power-supply unit.

- 1 Interconnecting cable.
- 1 Modulated r-f signal generator.
- 1 Output meter.
- 1 Multimeter (20,00-ohms-per-volt sensitivity; 50, 250, and 500-volt ranges).
- 1 Loud-speaker or headset.

INSTRUCTIONS

Remove the dust cover and bottom plate from the receiver. Connect the receiver to the power-supply unit, and plug the line cord into the a-c receptacle. Turn the OFF-ON switch ON and allow the receiver to warm up. Do not make any adjustments other than those outlined in the procedure.

PROCEDURE

1. Connect the output meter to the terminals marked SPKR at the rear of the receiver.
2. Connect the headset or loud-speaker to the receiver.
3. Adjust front-panel controls on the receiver as follows:

CONTROL	POSITION
SENSITIVITY	10
AUDIO GAIN	10
SIGNAL	MOD
AVC-MANUAL	MANUAL
LIMITER	OFF
CRYSTAL SELECTIVITY	OFF
SEND-REC	REC
BAND WIDTH	3
BAND SWITCH	2.5—5.0 mc.
BAND SPREAD	100

4. Set the signal-generator frequency for 465 kc., and the modulation for 30% at 400 cycles.
5. Check the operation of the 3rd i-f amplifier as follows:
 - a. Connect the signal-generator output lead through a 0.1-mf. capacitor to secondary test point (D1), located at the grid (pin 4) of the 3rd i-f amplifier tube, V7. Connect the ground lead of the signal generator to the chassis.
 - b. Adjust the signal generator attenuator for a 50-volt reading on the output meter.
 - c. A clear tone heard in the loud-speaker indicates that the stage is operating correctly.
6. Check the operation of the 2nd i-f amplifier as follows:
 - a. Apply the signal-generator output, as outlined in step 5 a, to test point (D2), located at the grid (pin 4) of the 2nd i-f amplifier tube.
 - b. A louder tone in the loud-speaker and a greater meter reading than were obtained in step 5 indicate that the stage is operating correctly.
 - c. Adjust the signal-generator attenuator for a 50-volt reading on the output meter. Note that less signal-generator input is necessary at test point (D2) than at test point (D1).
7. Check the operation of the 1st i-f amplifier as follows:

a. Apply the signal-generator output, as outlined in step 5 a, to test point (D3), located at the grid of the 1st i-f amplifier tube.

b. A louder tone in the loud-speaker and a greater meter reading than were obtained in step 6 indicate that the stage is operating correctly.

c. Adjust the signal-generator attenuator for a 50-volt reading on the output meter. Note that less signal-generator input is necessary at test point (D3) than at test point (D2).

8. Check the operation of the crystal-filter circuit as follows:

a. Apply the signal-generator output, as outlined in step 5 a, to test point (D4), located at the grid (grid cap) of the 1st-detector tube.

b. Switch the CRYSTAL SELECTIVITY switch to position 1.

c. A louder tone in the loud-speaker and a greater meter reading than were obtained in step 7 indicate that the 1st detector and crystal filter are operating correctly.

d. Adjust the signal-generator attenuator for a 50-volt reading on the output meter. Note that less signal-generator input is necessary at test point (D4) than at test point (D3). This indicates that the signal is amplified by the 1st detector.

9. Check alignment of the i-f section as follows:

a. With the signal generator still set for 465 kc., connect the output lead through a 250-mmF. capacitor to test point (D5). Connect the ground lead to the chassis.

b. Adjust the front-panel controls on the receiver as follows:

CONTROL	POSITION
MAIN TUNING	2.5 mc.
CRYSTAL SELECTIVITY	3
AVC-MANUAL	AVC

c. Turn off the modulation of the signal generator and adjust its frequency slightly for maximum deflection on the S meter.

d. Adjust the front-panel controls on the receiver as follows:

CONTROL	POSITION
SENSITIVITY	0
CRYSTAL SELECTIVITY	OFF
AVC-MANUAL	MANUAL

e. Adjust the SENSITIVITY control until a reading of 5 to 10 volts is obtained on the 10 or 20-volt range of the output meter.

f. Check the alignment of the single trimmer capacitor in transformer T4 for maximum reading on the output meter.

g. Check the alignment of both upper (grid) and lower (plate) air-trimmer capacitors in i-f transformer T3.

h. Check the alignment of both upper and lower air-trimmer capacitors in i-f transformer T2.

i. Check the alignment of L26 in the crystal filter by setting the lower adjusting screw on the side of the shield can, T1, for maximum reading on the output meter.

10. Disconnect the signal generator and output meter.

11. Set the front-panel controls on the receiver as follows:

CONTROL	POSITION
SENSITIVITY	0
AUDIO GAIN	0

12. Using the multimeter measure the voltages between the 1st, 2nd, and 3rd i-f amplifier tube-socket terminals and chassis. Record the reading in the following chart:

1ST I-F AMPLIFIER TUBE V5 (6K7)

PIN NO.	VOLTAGE	FUNCTION
1		
2		
3		
4		
5		
6		
7		
8		

2ND I-F AMPLIFIER TUBE V6 (6SK7)

PIN NO.	VOLTAGE	FUNCTION
1		
2		
3		
4		
5		
6		
7		
8		

3RD I-F AMPLIFIER TUBE V7 (6SK7)

PIN NO.	VOLTAGE	FUNCTION
1		
2		
3		
4		
5		
6		
7		
8		

13. Turn the power OFF-ON switch OFF and, using the ohmmeter part of the multimeter, measure the resistances between the chassis and the socket terminals indicated in the following chart:

1ST I-F AMPLIFIER STAGE V5 (6K7)

PIN NO.	OPERATING CONTROL	RESISTANCE IN OHMS	CIRCUIT COMPONENTS MEASURED	TUBE ELEMENT
Grid cap	AVC-MANUAL to AVC			
	AVC-MANUAL to MANUAL and SENSITIVITY to 0			
	AVC-MANUAL to MANUAL and SENSITIVITY to 10			
3				
4				

2ND I-F AMPLIFIER STAGE V6 (6SK7)

4	AVC-MANUAL to AVC			
	AVC-MANUAL to MANUAL and SENSITIVITY to 0			
	AVC-MANUAL to MANUAL and SENSITIVITY to 10			
6				
8				

3RD AMPLIFIER STAGE V7 (6SK7)

PIN NO.	OPERATING CONTROL	RESISTANCE IN OHMS	CIRCUIT COMPONENTS MEASURED	TUBE ELEMENT
4				
6				
8				

14. After completing this portion of the experiment request the instructor to put a trouble in the i-f amplifier section. Use the procedure outlined in steps 1 through 8 to check the over-all operation, and the procedure in steps 11 through 13 to locate the faulty component.

CONCLUSIONS

1. Which test point checks the over-all operation of the i-f section?

2. What type of signal is fed to test point **D3** ?

3. At what point is the signal fed to check the alignment of the i-f section?

4. If resistor R16 in the screen grid of the 1st i-f amplifier were to burn out what would be the voltage at the screen grid?

5. If an abnormal indication is obtained at test point

D, at what test point should the next test be made?



REVIEW No. 1



This review requires about three hours, and is to be conducted in the form of an oral quiz. Display Wall Charts No. 1 and No. 2, and review the important points contained in Lectures No. 1 through No. 7 and Experiments No. 1 through No. 5 by asking the questions contained in the Oral quiz of each Lesson Plan and the Conclusions of each Experiment. If any partic-

ular question causes the students difficulty, explain the answer fully. The students should be permitted, at regular intervals during the review, to ask questions of their own pertaining to the subject material. Make a note of each question on which the students indicate a general weakness.



EXAMINATION No. 1



This examination covers the material contained in Lectures No. 1 through No. 7 and Experiments No. 1 through No. 5. The normal time allotment for this examination is approximately two hours.

No reference material may be used during Part I of this examination. After Part I is finished, the instructor will collect the papers. Do not start Part II until given the signal by the instructor. The schematic diagram and the functional block diagram are necessary for answering the questions in Part II.

PART I MULTIPLE CHOICE

- One special use of the BC-779-B is as:
 - a receiver in an aircraft.
 - a broadcast-band receiver for general use.
 - a direction-finder receiver in fighter control.
 - a receiver in an aircraft control system for routing airplanes from point-to-point.
- The BC-779-B operates over a frequency range of:
 - 100 kc.—20 mc.
 - 100—400 kc.; 2.5—20 mc.
 - 100—400 kc.; 2—20 mc.
 - 1.25—40 mc.

- The sources of power from which the receiver may operate are:
 - a dynamotor or rectifier power-supply unit.
 - a dynamotor or battery supply.
 - a rectifier power-supply unit or battery supply.
 - a rectifier power-supply unit or vibrator power-supply unit.
- The operating frequency range of the receiver is divided into:
 - 2 bands.
 - 6 bands.
 - 10 bands.
 - 5 bands.
- The total power output of the receiver is about:
 - 20 watts.
 - 15 watts.
 - 3 watts.
 - 10 watts.
- The main purpose of the SEND-REC switch is to:
 - convert the receiver into a transmitter.
 - turn the power-supply unit off.
 - disable the receiver during transmissions, when the receiver is used in conjunction with a transmitter.

- d. switch the antenna from the receiver to the transmitter during transmissions, when the receiver is used in conjunction with a transmitter.
7. The PHASING control is effective whenever:
 - a. the SIGNAL switch is in CW position.
 - b. the CRYSTAL SELECTIVITY switch is in any one of the five numbered positions.
 - c. the AVC-MANUAL switch is in the MANUAL position.
 - d. the receiver is turned on.
8. The beat-frequency oscillator is in operation whenever:
 - a. the SIGNAL switch is in CW position.
 - b. the CRYSTAL SELECTIVITY switch is in any one of the five numbered positions.
 - c. the AVC-MANUAL switch is in MANUAL position.
 - d. the receiver is turned on.
9. The BC-779-B is a:
 - a. super-regenerative type of receiver.
 - b. tuned-radio-frequency type of receiver.
 - c. regenerative type of receiver.
 - d. superheterodyne type of receiver.
10. The BC-779-B is designed to receive:
 - a. only modulated signals.
 - b. modulated and C-W signals.
 - c. only C-W signals.
 - d. only frequency-modulated signals.
11. If the receiver is tuned for a 3000-kc. signal, the h-f oscillator will oscillate at:
 - a. 3465 kc.
 - b. 2535 kc.
 - c. 465 kc.
 - d. 3000 kc.
12. The crystal-filter circuit is designed to:
 - a. decrease the selectivity of the receiver.
 - b. decrease the noise level of the receiver.
 - c. increase the selectivity of the receiver.
 - d. increase the sensitivity of the receiver.
13. To check the operation of the entire audio amplifier section:
 - a. an audio-frequency signal is fed to the grid of the 3rd i-f amplifier.
 - b. an audio-frequency signal is fed to the grid of the 1st audio-amplifier.
 - c. an audio-frequency signal is fed to the grid of audio driver.
 - d. an intermediate-frequency signal is fed to the grid of the 1st i-f amplifier.
14. The BC-779-B employs:
 - a. two r-f stages for preselection.
 - b. one r-f stage for preselection.
 - c. three i-f stages for preselection.
 - d. only the antenna circuit for preselection.
15. The impedance of the antenna input circuit averages approximately:
 - a. 300 ohms.
 - b. 200 ohms.
 - c. 150 ohms.
 - d. 100 ohms.
16. The r-f tuned circuits are aligned at the:
 - a. low and high end of each band.
 - b. high end of each band.
 - c. low end of each band.
 - d. low and high end of only the high-frequency bands.
17. The BANDSPREAD control is only effective on the:
 - a. 100—200-kc., 200—400-kc. bands.
 - b. 2.5—5.0-mc., 5.0—10.0-mc., and 10.0—20.0-mc. bands.
 - c. 200—400-kc., 2.5—5.0-mc., 5.0—10.0-mc., and 10.0—20.0-mc. bands.
 - d. 5.0—10.0-mc. and 10.0—20.0-mc. bands.
18. The output frequency of the 1st detector is:
 - a. 930 kc.
 - b. 465 kc.
 - c. 564 kc.
 - d. 654 kc.
19. The h-f oscillator is a conventional type:
 - a. electron-coupled oscillator.
 - b. Hartley oscillator.
 - c. ultraudion oscillator.
 - d. Colpitts oscillator.
20. The equivalent circuit of the crystal used in the crystal-filter circuit is:
 - a. a parallel-resonant circuit in parallel with the shunt capacitance of the crystal.
 - b. a series-resonant circuit in series with the shunt capacitance of the crystal.
 - c. a series-resonant circuit in parallel with the shunt capacitance of the crystal.
 - d. a parallel-resonant circuit in series with the shunt capacitance of the crystal.
21. When the CRYSTAL SELECTIVITY switch is in position 5:
 - a. the selectivity of the over-all circuit is average.
 - b. the selectivity of the over-all circuit is the lowest.
 - c. the sensitivity of the over-all circuit is the greatest.
 - d. the selectivity of the over-all circuit is the greatest.
22. The band width of the i-f amplifier section with the crystal removed from the circuit is:
 - a. variable from 16 kc. to 3 kc.
 - b. variable from 16 kc. to 6 kc.
 - c. 16 kc.
 - d. variable from 16 kc. to 100 cycles.

23. The intermediate frequency is:

- a. 456 kc.
- b. 465 kc.
- c. 4560 kc.
- d. 654 kc.

24. Poor i-f alignment has no effect upon:

- a. over-all sensitivity.
- b. dial calibration.
- c. selectivity.
- d. audio-amplifier distortion.

25. When aligning the i-f amplifier the tuned circuits are adjusted for:

- a. a "peak" reading on the output meter.
- b. a "dip" in the output meter reading.
- c. a "dip" in the "S"-meter reading.
- d. a midpoint reading on the "S" meter.

ESSAY QUESTIONS

26. Name the three features of the receiver which make it useful as a communications receiver.

27. Briefly explain the differences between the three power-supply units.

28. How will the operating frequency of the receiver be affected if the BAND SPREAD dial is varied from 100 to 0?

29. Briefly explain how the "S" meter may be used as a tuning guide to indicate the accuracy of the tuning.

30. Draw the functional block diagram of the equipment.

PART II

MULTIPLE CHOICE

31. An incorrect voltage measured at major test point **1** indicates trouble in:

- a. the "C"-bias rectifier.
- b. the high-voltage rectifier.
- c. either the "C"-bias or high-voltage rectifier, or both.
- d. the receiver circuits.

32. To check the operation of the h-f oscillator, connect:

- a. r-f signal generator at key test point **E**.
- b. an r-f signal generator at key test point **F**.
- c. a 20,000-ohms-per-volt voltmeter at key test point **E**.
- d. a 20,000-ohms-per-volt voltmeter at key test point **F**.

33. The primary coils of the antenna input transformers are electrostatically shielded from the secondaries to:

- a. reduce extraneous noise pickup.
- b. eliminate fading.
- c. increase the gain of the stage.
- d. increase the coupling.

34. The purpose of capacitor C6 and resistor R4 in the plate circuit of the 1st r-f amplifier is to:

- a. prevent any r-f energy from entering the power supply.
- b. couple the signal to the 2nd r-f grid.
- c. decrease the regenerative feedback to the grid circuit.
- d. eliminate the unwanted frequencies from the 1st r-f amplifier.

35. If capacitor C5 in the screen-grid circuit of the 1st r-f amplifier were to short, the receiver would become inoperative due to:

- a. low plate voltage on the 1st r-f tube.
- b. excessive screen-grid current in the 1st r-f tube.
- c. excessive plate current in the 1st r-f tube.
- d. no screen-grid voltage on the 1st r-f tube.

36. If the output connection of the signal generator is moved from test point **F3** to test point **F**, without changing the settings of the SENSITIVITY and AUDIO GAIN controls, the output-meter reading should:

- a. decrease.
- b. increase.
- c. remain the same.
- d. be zero.

37. If capacitor C15 in the grid circuit of the h-f oscillator were to become shorted:

- a. the h-f oscillator would not oscillate.
- b. the h-f oscillator would become detuned.
- c. there would be no noticeable change in the operation of the oscillator.
- d. the h-f oscillator tube would burn out.

38. The h-f oscillator output to the 1st detector is obtained from:

- a. the plate of the h-f oscillator.
- b. the grid of the h-f oscillator.
- c. the plate and grid of the h-f oscillator.
- d. the cathode of the h-f oscillator.

39. The h-f oscillator is tuned:

- a. inductively on the low-frequency end of each band.
- b. inductively on the high-frequency end of each band.
- c. inductively on the low-frequency end of the three high-frequency bands, and capacitively on the two low-frequency bands.
- d. capacitively on the low-frequency end of each band.

40. Which one of the following functional block(s) would be misaligned if the dial were accurately calibrated on all bands except the 2.5—5.0-mc. band?

- a. h-f oscillator.
- b. 1st detector.
- c. all three i-f amplifiers.
- d. both r-f amplifiers.

41. Adjusting the CRYSTAL SELECTIVITY switch from position 3 to position 5:

- a. increases the selectivity of the receiver.
- b. decreases the selectivity of the receiver.
- c. moves the rejection notch below 465 kc.
- d. moves the rejection notch above 465 kc.

42. If crystal Y1 in the crystal-filter circuit were to become short-circuited:

- a. the receiver would become inoperative.
- b. the receiver would have excessive selectivity.
- c. the receiver would operate normally.
- d. the CRYSTAL SELECTIVITY switch would not have any effect on the receiver selectivity.

43. The BAND WIDTH CONTROL varies the coupling between the primary and secondary windings of the:

- a. 1st i-f transformer.
- b. 2nd i-f transformer.
- c. 2nd and 3rd i-f transformers.
- d. 3rd and 4th i-f transformers.

44. A-v-c voltage is applied to the grids of the:

- a. 1st and 2nd r-f amplifiers and 1st and 2nd i-f amplifiers.
- b. both r-f amplifiers, 1st detector, and all three i-f amplifiers.
- c. 1st r-f amplifier and 1st i-f amplifier.
- d. 1st and 2nd i-f amplifiers.

45. Three stages of i-f amplification are used to provide:

- a. a greater degree of stability.
- b. a greater degree of selectivity and stability.
- c. a greater degree of sensitivity.
- d. a greater signal-to-noise ratio.

ESSAY QUESTIONS

46. Briefly describe the method of aligning the tuned circuits in the r-f amplifier and 1st-detector grid circuits.

47. Briefly explain how the BEAT OSCILLATOR control is used in conjunction with the PHASING control to reduce the interference when the desired signal and stations on both sides of the desired signal are received simultaneously?

48. If resistor R42 in the crystal-filter circuit were to become open circuited, how would the operation of the receiver be affected?

49. Which test point, or test points, in the i-f section would indicate abnormal operation if tube V6 were to become defective?

50. At what test point is the i-f signal applied for checking the alignment of the i-f section?

► REVIEW OF EXAMINATION No. 1 ◀

Display Wall Charts No. 1 and No. 2 and, using the examination, review each question and give the correct answer. This review normally requires about one hour. Fully explain any question which causes the students difficulty, and make a note of the question for

future reference. At regular intervals the students should be allowed to ask questions of their own and engage in classroom discussions pertaining to those questions.

LECTURE No. 8

CIRCUIT ANALYSIS OF 2nd DETECTOR AND NOISE LIMITER

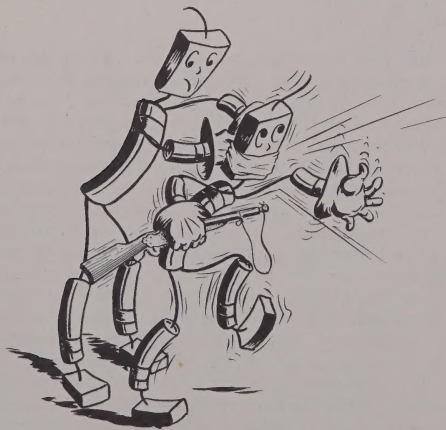
The 2nd detector rectifies the amplified i-f signal from the output of the 3rd i-f amplifier, and feeds the audio component to the audio-amplifier section. The noise limiter, which works in conjunction with the 2nd detector, when turned on prevents any sudden surges of noise interference above the level of the audio signal from entering the audio-amplifier section. Figure 17 shows the simplified schematic of the 2nd-detector and noise-limiter circuit.

The 2nd-detector circuit is a conventional half-wave rectifier, which is designed to provide a minimum of distortion. Referring to the simplified schematic (figure 17), assume that switch SW5 is open and that

the noise limiter is inoperative. The output from the 3rd i-f amplifier tube, V7, is applied through transformer T4 to the 2nd-detector tube V8. The 2nd-detector tube is a 6H6 duo-diode, with the two plates tied together and the two cathodes tied together. One lead of L32, the untuned secondary of T4 is connected to the plates of V8, and the other lead is returned to ground through resistors R48 and R24 and the parallel combination of resistor R25 and potentiometer R26. With no signal being received there is no current through tube V8. When a signal is received, the positive half cycles of the i-f signal voltage across L32 cause current to flow in the plate cir-

R48. Since the plate of V9 is connected to the cathode end of resistor R30 in the cathode of the 2nd detector, the plate is made positive by the voltage developed across resistor R30. Capacitor C26 by-passes any i-f variations in voltage from the plate to ground.

The relative potentials of the cathode, grids, and plates of the limiter tube depend upon the current flowing in the 2nd-detector load and cathode circuits, and this current in turn depends upon the i-f carrier voltage impressed on the diode plates. When there is no modulation on the carrier, the control grids of limiter tube V9 are much more negative than the cathode; hence, the plate-to-cathode resistance is high and very little conduction takes place in the tube. Due to resistor R31 in series with the filament, tube V9 operates with only about 4 volts applied to the filament. This decreases the current in the tube considerably when the operating voltages on the tube elements are as described. When a modulated carrier is received, the balance in voltage is upset due to the audio voltage developed across the diode load. The cathode voltage varies, but the grid voltage remains constant due to the large time constant of the filter circuit (R49 and C42). Therefore, some conduction takes place on the positive peaks of the audio voltage. For modulation percentages up to about 50% this conduction has no noticeable effect upon the audio signal, but as the modulation increases the tube will conduct more and the clipping of the positive peaks will result in distortion in the output of the detector. When a noise pulse of very short duration is superimposed upon the carrier, the current through the diode load is greatly increased. Due to the time constant of the filter (R49 and C42), the grids of the limiter tube, V9, remain at their original potential, while the cathode goes more negative and the plates more positive. If the pulse is strong enough, the cathode will be driven negative with respect to the control grids, causing a very low plate-to-cathode resistance. Since this low-resistance path is in shunt with resistor R24, resistor R25, and potentiometer R26 in the diode load circuit and resistor R30 in the diode cathode circuit, very little current will flow through potentiometer R26, the AUDIO GAIN control, during noise pulses. Therefore, all noise pulses are prevented from reaching the audio-amplifier section.



Assuming that the 3rd i-f amplifier and the audio-amplifier section are functioning properly, test point **DP1**, located at the grid of the 3rd i-f amplifier, may be used to check the operation of the 2nd detector. If a 465-kc. signal modulated at about 400 cycles is introduced at this test point, a clear tone in the speaker will indicate that the 2nd detector is functioning correctly.

The noise-limiter action may be checked by tuning in a phone signal on a noisy band and turning the LIMITER switch ON. A reduction in the audio level with an improved signal-to-noise ratio should be noticed.

LESSON PLAN No. 8

TIME ALLOTTED: 1 HR.

SUBJECT

Circuit analysis of 2nd detector and noise-limiter.

OBJECTIVE

To provide an understanding of the function and operation of the 2nd-detector and noise-limiter circuits and their associated components.

INTRODUCTION

A conventional diode-type 2nd detector is employed to remove the audio frequency component from the i-f signal. The noise-limiter circuit automatically shorts out the audio signal from the 2nd detector during noise pulses of short duration.

SUBJECT MATERIAL

1. Locate the 2nd-detector and noise-limiter circuits on the functional block diagram, Wall Chart No. 1, and review the over-all function of these circuits in the receiver.
2. Locate the 2nd-detector and noise-limiter circuits on the schematic diagram, Wall Chart No. 2.
3. Draw the simplified schematic (figure 17) on the blackboard.
4. Explain how the signal is fed to the 2nd detector from the 3rd i-f stage.
5. Discuss the type of tube used in the 2nd detector.
6. Discuss the components in the plate circuit of the 2nd detector.
7. Discuss the operation of the 2nd detector when no signal is received.
8. Discuss the operation of the 2nd detector when a signal is received.
9. Explain how the output of the 2nd detector is fed to the 1st a-f amplifier.
10. Discuss the type of tube used in the noise limiter and explain the over-all functioning of the stage.
11. Explain how the LIMITER switch turns the noise limiter on.
12. Discuss the components in the grid circuit, and the type of voltage applied to the grid.
13. Discuss the components in the cathode circuit, and the type of voltage applied to the cathode.
14. Discuss the components in the plate circuit and the type of voltage applied to the plate.
15. Discuss the relationship of voltages at the various elements.
16. Discuss the operation of the noise limiter when an unmodulated carrier is received.

17. Discuss the operation of the noise limiter when a modulated carrier is received.

18. Discuss the operation of the noise limiter when a noise pulse of short duration is received with the carrier.

19. Discuss the method of checking the 2nd-detector operation.

20. Discuss the method of checking the operation of the noise limiter.

CONCLUSIONS

The purpose of the second detector is to rectify the i-f signal from the 3rd i-f amplifier and feed the detected audio signal, with a minimum of distortion, to the audio-amplifier section. The noise limiter is designed to increase the signal-to-noise ratio of the audio output by reducing the level of any noise of short duration.

ORAL QUIZ

1. What type of 2nd-detector circuit is used?

2. How does the AUDIO GAIN control operate?

3. What stage supplies the input to the 2nd detector?

4. What type of tube is used in the 2nd-detector circuit?

5. What is the primary purpose of the noise-limiter circuit?

6. What type of tube is used in the noise-limiter circuit?

7. How does the LIMITER switch put the limiter circuit in operation?

8. What circuit elements in the noise limiter permit it to adjust itself for gradual carrier variations, and yet not follow the normal carrier variations due to modulation?

9. How does the noise limiter eliminate the noise pulses from the audio-amplifier section?

10. How may the operation of the 2nd detector be checked?

EXPERIMENT No. 6

TIME ALLOTTED: 2 HR.

SUBJECT

2nd detector and noise limiter.

OBJECTIVE

To trouble-shoot and check the operation of the 2nd-detector and noise-limiter circuits.

EQUIPMENT REQUIRED

- 1 Radio Receiver BC-779-B.
- 1 Power-supply unit.
- 1 Interconnecting cable.
- 1 Modulated r-f signal generator.
- 1 Multimeter (20,000-ohms-per-volt sensitivity; 50, 250, and 500-volt ranges).
- 1 Loud-speaker or headset.

INSTRUCTIONS

Remove the dust cover and bottom plate from the receiver. Connect the receiver to the power-supply unit, and plug the line cord into the a-c receptacle. Turn the OFF-ON switch ON and allow the receiver to warm up. Do not make any adjustments other than those outlined in the procedure.

PROCEDURE

1. Connect the headset or loud-speaker to the receiver.
2. Adjust the front-panel controls as follows:

CONTROL	POSITION
SENSITIVITY	0
AUDIO GAIN	10
SIGNAL	MOD
LIMITER	OFF
SEND-REC	REC

3. Check the operation of the 2nd detector as follows:

a. Adjust the signal generator for 465 kc., with the modulation on.

b. Connect the output lead of the signal generator through a .01-mf. capacitor to secondary test point (D1), located at the grid (pin 4) of the 3rd i-f amplifier; connect the ground lead to the chassis.

c. A clear tone should be heard in the output of the receiver.

NOTE: A good indication of the 2nd-detector operation cannot be obtained by applying the signal-generator signal directly to the 2nd detector; therefore, the signal is fed to the grid of the 3rd i-f amplifier. If no output is obtained from the loud-speaker, the 3rd i-f amplifier should be checked first by taking voltage and resistance measurements as outlined in Experiment No. 5. If the 3rd i-f amplifier is operating correctly, then the 2nd-detector circuit is checked by taking voltage and resistance measurements as outlined in this experiment.

4. Check the operation of the noise limiter as follows:

a. Set the SENSITIVITY control to 10, and tune in a modulated signal on a noisy band; carefully listen to the output of the receiver.

b. Turn the LIMITER switch to ON. A reduction of the audio volume with an improvement in the signal-to-noise ratio should be noticed.

5. Adjust the SENSITIVITY and AUDIO GAIN controls to 0.

6. Using the multimeter measure the voltage between the 2nd-detector and noise-limiter tube-socket

terminals and chassis. Record the readings in the following chart:

2ND-DETECTOR TUBE V8 (6H6)

PIN No.	VOLTAGE	FUNCTION
1		
2		
3		
4		
5		
6		
7		
8		

NOISE-LIMITER TUBE V9 (6N7)

1		
2		
3		
4		
5		
6		
7		
8		

7. Turn the power OFF-ON switch to OFF and, using the ohmmeter part of the multimeter, measure the resistances between the chassis and the socket terminals indicated in the chart below.

8. After completing this portion of the experiment request the instructor to put a trouble in the 2nd-detector and noise-limiter circuits. Use the procedure in steps 1 through 4 to check the over-all operation of these circuits. Use the procedure in steps 5 through 7 to locate the faulty component.

CONCLUSIONS

1. Why is test point $\textcircled{D1}$ used to check the operation of the 2nd detector?

2. If resistor R30 in the cathode of the 2nd detector were to burn out, what would be heard in the loud-speaker?

3. If resistor R31 in series with the filament of the noise-limiter tube were to burn out, how would the operation of the noise-limiter circuit be affected?

4. If capacitor C42 were defective (open circuit), how would the operation of the noise-limiter circuit be affected?

5. If capacitor C45 were defective (short circuit), what would be heard in the loud-speaker?

2ND-DETECTOR TUBE V8 (6H6)

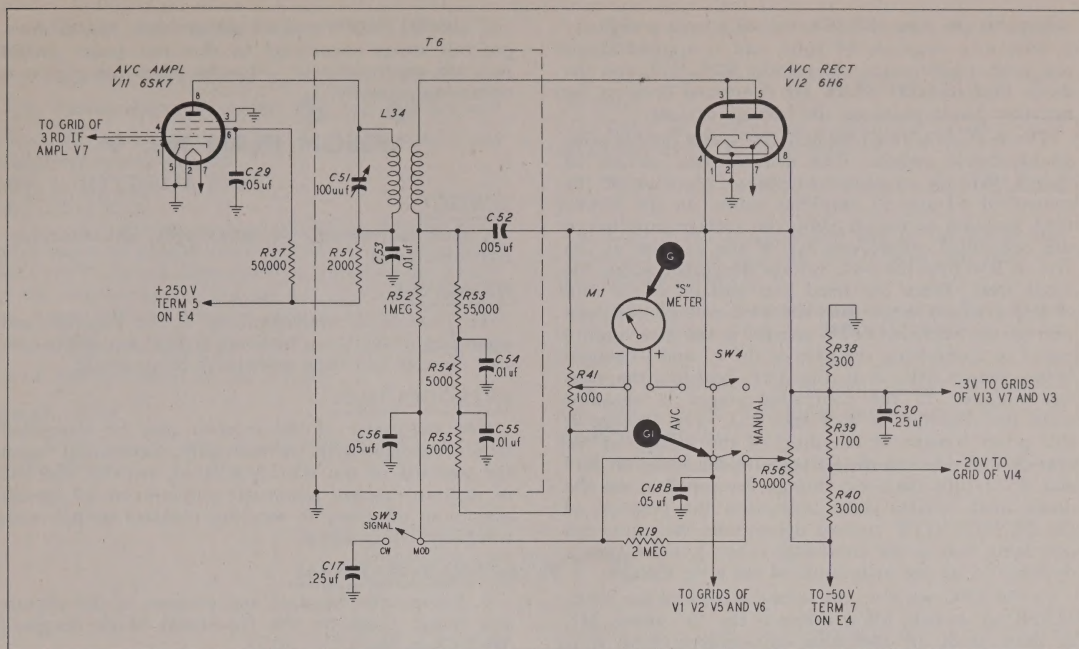
PIN No.	OPERATING CONTROL	RESISTANCE IN OHMS	CIRCUIT COMPONENTS MEASURED	TUBE ELEMENT
3 or 5				
4 or 8				
NOISE-LIMITER TUBE V9 (6N7)				
3 or 6				
4 or 5				
7				
8	LIMITER switch to ON LIMITER switch to OFF			

LECTURE No. 9

CIRCUIT ANALYSIS OF A-V-C BIAS-SUPPLY AND SENSITIVITY-CONTROL CIRCUITS

The automatic-volume-control system automatically controls the sensitivity of the two r-f stages and the first two i-f stages, to compensate for variations in signal strength due to fading. The sensitivity of the controlled stages is manually adjusted by the manual SENSITIVITY control incorporated in the a-v-c system. A fixed-bias system provides a negative 20 volts

for the grid of the a-f driver stage, and a negative 3 volts for the a-v-c system and the grids of the 1st detector (V3), 3rd i-f amplifier (V7), and 1st a-f amplifier (V13). Figure 18 shows the simplified schematic of the a-v-c bias-supply, and sensitivity-control circuits.



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Figure 18. A-V-C, Bias-Supply, and Sensitivity-Control Circuits

The a-v-c system employs special amplifier and rectifier stages to obtain maximum efficiency. The a-v-c amplifier stage, V11, operates as a conventional intermediate-frequency amplifier, and uses a 6SK7 remote-cut-off pentode. The suppressor grid and cathode of V11 are connected directly to ground. The control grid is connected directly in parallel (through a shielded lead) with the control grid of the 3rd i-f amplifier, V7, which is driven by the signal from the tap on secondary coil L31 of i-f transformer T3. A positive 250 volts, obtained from terminal 5 on terminal strip E4, is applied to the screen grid through screen dropping resistor R37; capacitor C29 by-passes the screen grid to ground for radio frequencies. The positive 250 volts is also applied to the plate of V11 through the decoupling network, consisting of resistor R51 and capacitor C53, and the primary coil of L34 in transformer T6. The amplified i-f signal in the plate circuit is coupled through the tuned circuit, consisting of the primary coil of transformer T6 and capacitor C51, to the untuned secondary coil, L34, in the plate circuit of the a-v-c rectifier tube, V12.

The a-v-c rectifier is a 6H6 duo-diode, with each diode section connected in parallel to form a half-wave rectifier circuit. The plate load circuit consists of the untuned secondary of transformer T6 in series with resistors R53, R54, R55, and R41 which is connected to the paralleled cathodes. On positive half cycles of the i-f signal voltage, present across the untuned secondary coil of T6, current flows in the plate circuit of the diode, developing a d-c voltage across the diode load resistors. Capacitors C52, C54, and C55 are filters, which aid in removing all variations in the d-c voltage. The magnitude of this voltage is deter-

mined by the strength of the incoming signal. The negative a-v-c voltage is fed from the junction of the secondary coil of transformer T6 and resistor R53 through the a-v-c filter arrangement, consisting of resistor R52 and by-pass capacitor C56, to the a-v-c terminals on the AVC-MANUAL switch, SW4. The time constant of this resistor-capacitor combination is very large, in order to prevent the a-v-c voltage from following the audio modulation. When a.v.c. is used for c-w code reception, a larger time constant is desirable to prevent the sensitivity of the receiver from varying when the carrier is keyed. This is secured by adding a .25-microfarad capacitor, C17, in parallel with capacitor C56, through the closed contacts of one section of the SIGNAL switch, SW3, when it is in CW position. Therefore, whenever switch SW3 is placed in CW position for code reception, capacitor C17 is automatically added to the a-v-c system. The low-potential end of the a-v-c rectifier diode load, which is at the junction of the paralleled cathodes of the diode, V12, and resistor R41, is returned to the negative 3-volt point on the "C"—bias voltage divider. This provides the minimum recommended grid bias for the controlled r-f and i-f amplifier tubes (V1, V2, V5, and V6) independent of the a-v-c voltage.

The 2-megohm resistor, R19, is connected between the a-v-c filter network (R52 and C56), at the a-v-c terminal of the AVC-MANUAL switch, SW4, and the arm of the SENSITIVITY control, R56, which is connected to the MANUAL terminal of switch SW4. The SENSITIVITY control, R56, is connected between the negative 3-volt junction of resistors R38 and R39 on the "C"—bias voltage divider and the negative 50-volt terminal (terminal 7) on terminal strip E4. Thus the

voltage at the arm of R56 is variable from a negative 3 volts to a negative 50 volts, and is applied across the series combination of resistors R19, R52, and the diode load resistors which are connected back to the negative 3-volt point on the voltage divider.

The AVC-MANUAL switch, SW4, is a double-pole, double-throw switch. The arm of one section of switch SW4 is connected to the grid circuit of the controlled r-f and i-f amplifier tubes. In the MANUAL position of switch SW4, the voltage supplied to the controlled stages consists of the voltage at the arm of R56 plus the a-v-c voltage developed across the diode load. Since the fixed bias voltage at the arm of R56 is much larger than the a-v-c voltage, the position of the SENSITIVITY control is the determining factor in controlling the gain of the r-f and i-f stages. When switch SW4 is in the AVC position, the voltage supplied to the controlled stages is obtained from the junction of R19 and R52. The voltage at this point consists of one-third of the voltage at the arm of R56 (due to the voltage-divider action of R19 and R52) plus the a-v-c voltage developed across the diode load. Under these conditions the position of the SENSITIVITY control determines the minimum operating bias of the controlled tubes, but the gain is determined by the magnitude of the a-v-c voltage.

In the AVC position, the second section of the AVC-MANUAL switch, SW4, connects the "S" meter, M1, in shunt with the 1800-ohm adjustable resistor, R41. Since resistor R41 is in series with the a-v-c diode load, some of the rectified current flows through the meter. The amount of this current depends upon the strength of the i-f voltage impressed on the plates of the a-v-c diode. This voltage, in turn, depends upon both the strength of the incoming signal and the accuracy of tuning. The meter reading varies as the receiver is tuned through a signal, the highest reading occurring at exact resonance. Since strong signals produce higher meter readings than weak signals, the actual meter reading at resonance is an indication of the strength of the incoming signal carrier. The setting of variable resistor R41 controls the degree of meter deflection on any given signal, and is usually adjusted to produce a reading of "S9" for a 50-microvolt signal at 3.5 mc. When properly adjusted, a change of one "S" number on the meter indicates a change in signal strength of approximately two to one. The SENSITIVITY control, R56, must be turned full on (10) for maximum "S"-meter accuracy.

In the alignment of the a-v-c circuit, for maximum operating efficiency the single trimmer capacitor in transformer T6 is adjusted for a minimum output-meter reading while an i-f signal is fed to the 1st-detector stage. The "S"-meter reading should "peak" at the same time that the output-meter reading "dips."

In checking the operation of the a-v-c circuit, two test points are employed. Key test point ⑥, at the "S" meter, checks the over-all operation of the a-v-c circuit. When the AVC-MANUAL switch is on AVC and the receiver is tuned to a strong phone station, the "S" meter should deflect to the right, indicating that the a-v-c amplifier (V11) and a-v-c rectifier (V12) are operating correctly. Secondary test point ⑥1, located at the arm of the a-v-c section of the AVC-MANUAL switch, checks the action of the a-v-c filter circuit and the sensitivity-control circuit. With

the SENSITIVITY control set at 10, a 20,000-ohms-per-volt meter connected to this test point should indicate approximately -8 volts when the circuit is operating properly.

LESSON PLAN No. 9

TIME ALLOTTED: 1 HR.

SUBJECT

Circuit analysis of a-v-c, bias-supply, and sensitivity-control circuits.

OBJECTIVE

To provide an understanding of the function and operation of the a-v-c, bias-supply, and sensitivity-control circuits and their associated components.

INTRODUCTION

The sensitivity of the receiver may be controlled either automatically or manually, depending upon the position of the AVC-MANUAL switch. The use of separate-channel automatic volume control insures maximum efficiency in securing constant output with a rapidly fading signal.

SUBJECT MATERIAL

1. Review the function and purpose of the circuits and locate them on the functional block diagram, Wall Chart No. 1.
2. Locate the circuits on the schematic diagram, Wall Chart No. 2.
3. Draw the simplified schematic (figure 18) on the blackboard.
4. Discuss the over-all function of the a-v-c amplifier stage.
5. Discuss the type of tube employed in the a-v-c amplifier stage, and explain how the suppressor grid and cathode are connected.
6. Discuss the grid circuit of the a-v-c amplifier.
7. Discuss the screen-grid circuit of the a-v-c amplifier.
8. Discuss the plate circuit of the a-v-c amplifier and the manner in which the signal is fed to the a-v-c rectifier stage, V12.
9. Discuss the type of tube used for the a-v-c rectifier, and explain how it is connected as a single diode.
10. Discuss the components in the plate circuit.
11. Discuss the voltage developed across the diode load, and the function of each of the components when a signal is applied to the diode plate.
12. Discuss the function and operation of the a-v-c filter, R52 and C56.
13. Discuss the purpose of connecting C17 across the a-v-c filter, in the CW position of the SIGNAL switch.
14. Discuss the purpose of connecting the low-potential end of the diode load to the negative 3 volts from the "C"-bias voltage divider.
15. Discuss the function of resistor R19.
16. Discuss the function of the SENSITIVITY control, and the manner in which it is connected.
17. Discuss the type of switch used as the AVC-MANUAL switch, and explain how it is connected.
18. Discuss the function of the AVC-MANUAL switch in the MANUAL position.
19. Discuss the function of the AVC-MANUAL switch in the AVC position.

20. Discuss the function and operation of the "S" meter.

21. Discuss the method of aligning the a-v-c section.

22. Explain how test points **G** and **G₁** are employed in trouble-shooting the a-v-c, bias-supply, and sensitivity-control circuits.

CONCLUSIONS

The a-v-c channel employs special amplifier and rectifier stages to obtain maximum efficiency. The SENSITIVITY control determines the signal-to-noise ratio of the receiver by varying the bias applied to the two r-f stages and the 1st and 2nd i-f stages. Two test points, **G** and **G₁**, are used to trouble-shoot and check the operation of the circuits.

ORAL QUIZ

1. What type of tube is employed in the a-v-c amplifier stage?

2. What signal is fed to the grid of the a-v-c amplifier?

3. What type of tube is employed in the a-v-c rectifier stage?

4. What determines the magnitude of the voltage developed across the diode load?

5. What is the function of the a-v-c filter, R52 and C56?

6. Why is the low-potential end of the diode load connected to the negative 3-volt point on the "C"-bias voltage divider?

7. Why is the .25-microfarad capacitor, C17, added to the a-v-c filter when the SIGNAL switch is in CW position?

8. To which stages is the a-v-c voltage fed as bias?

9. When is the "S" meter connected in the a-v-c diode-load circuit?

10. What is the primary function of the "S" meter?

EXPERIMENT No. 7

TIME ALLOTTED: 2 HR.

SUBJECT

A-v-c bias-supply, and sensitivity-control circuits.

OBJECTIVE

To trouble-shoot and check the operation of the a-v-c, bias-supply, and sensitivity-control circuits.

EQUIPMENT REQUIRED

- 1 Radio Receiver BC-779-B.
- 1 Power-supply unit.
- 1 Interconnecting cable.
- 1 Modulated r-f signal generator.
- 1 Output meter.
- 1 Multimeter (20,000-ohms-per-volt sensitivity; 50, 250, and 500-volt ranges).
- 1 Loud-speaker or headset.

INSTRUCTIONS

Remove the dust cover and bottom plate from the receiver. Connect the receiver to the power-supply unit and plug the line cord into the a-c receptacle. Turn the OFF-ON switch ON and allow the receiver to warm up. Do not make any adjustments other than those outlined in the procedure.

PROCEDURE

- 1. Connect the loud-speaker or headset to the receiver.
- 2. Connect the output meter to the terminals marked SPKR at the rear of the receiver.
- 3. Adjust the receiver front-panel controls as follows:

CONTROL	POSITION
SENSITIVITY	10
AUDIO GAIN	0
SIGNAL	MOD

CONTROL	POSITION
AVC-MANUAL	AVC
LIMITER	OFF
CRYSTAL SELECTIVITY	OFF
SEND-REC	REC
BAND WIDTH	3
BAND SWITCH	2.5—5.0 mc.
BAND SPREAD	100

4. Check the over-all operation of the a-v-c circuits as follows:

- a. Locate a strong phone station on any band.
- b. Observe the "S" meter (designated as test point

G) when tuning through the selected station. The "S" meter should deflect to the right as the signal is being tuned in.

- c. Return the band switch to 2.5—5.0 mc.

5. Set the signal-generator frequency for 465 kc., and the modulation for 30% at 400 cycles.

6. Check the alignment of the a-v-c amplifier stage as follows:

a. Connect the output lead of the signal generator through a .01-microfarad capacitor to the grid of the a-v-c amplifier tube (pin 4 on V11). Connect the ground lead of the signal generator to the chassis.

b. Adjust the AUDIO GAIN control for a half-scale reading on the output meter.

c. Check the adjustment of the single trimmer capacitor in T6 for a minimum output-meter reading. The "S"-meter reading should be maximum at the same time that the output-meter reading is minimum, when tuning through a signal.

7. Disconnect the signal generator and output meter from the receiver.

8. Check the operation of the a-v-c and sensitivity-control circuits, at the a-v-c bus as follows:

- a. Connect the negative lead of the multimeter (set for the 0—10-volt d-c range) to test point **G₁**,

located at the a-v-c section of the AVC-MANUAL switch. Connect the positive lead to ground.

b. Adjust the SENSITIVITY control to 10.

c. The voltmeter should read approximately 8 volts.

9. Using the voltmeter section of the multimeter, measure the voltages between the a-v-c amplifier and a-v-c rectifier tube-socket terminals and the chassis. Record the voltages in the following chart.

A-V-C AMPLIFIER TUBE V11 (6SK7)

PIN No.	VOLTAGE	FUNCTION
1		
2		
3		
4		
5		
6		
7		
8		

A-V-C RECTIFIER TUBE V12 (6H6)

1		
2		
3		
4		
5		
6		
7		
8		

10. Turn the power OFF-ON switch OFF and, using the ohmmeter section of the multimeter, measure the resistances between the chassis and the socket terminals indicated in the following chart. Record the measurements in the chart.

A-V-C AMPLIFIER STAGE

PIN No.	RESISTANCE IN OHMS	CIRCUIT COMPONENTS MEASURED	TUBE ELEMENT
4			
6			
8			

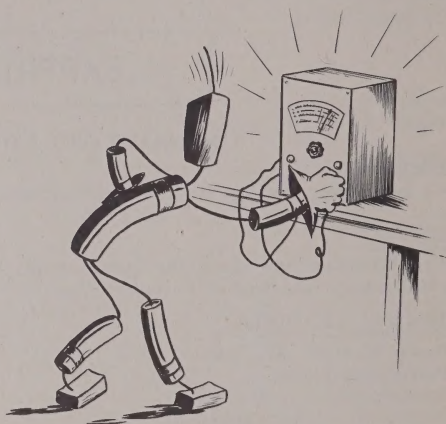
A-V-C RECTIFIER STAGE

3 or 5			
4 or 8			

11. After completing this portion of the experiment request the instructor to put a trouble in the a-v-c bias-supply, and sensitivity-control circuits. Use the procedure outlined in steps 1 through 7 to check the over-all operation of these circuits. Use the procedure in steps 8 and 9 to locate the faulty components.

CONCLUSIONS

1. Why should the output meter "dip" while the "S" meter "peaks" when tuning through a station?
2. What adjustment is used to align the a-v-c amplifier for minimum output-meter reading?
3. What is the function of test point ⑥?
4. Where is test point ⑥ located?
5. What circuits are affected by the SENSITIVITY control?



LECTURE No. 10

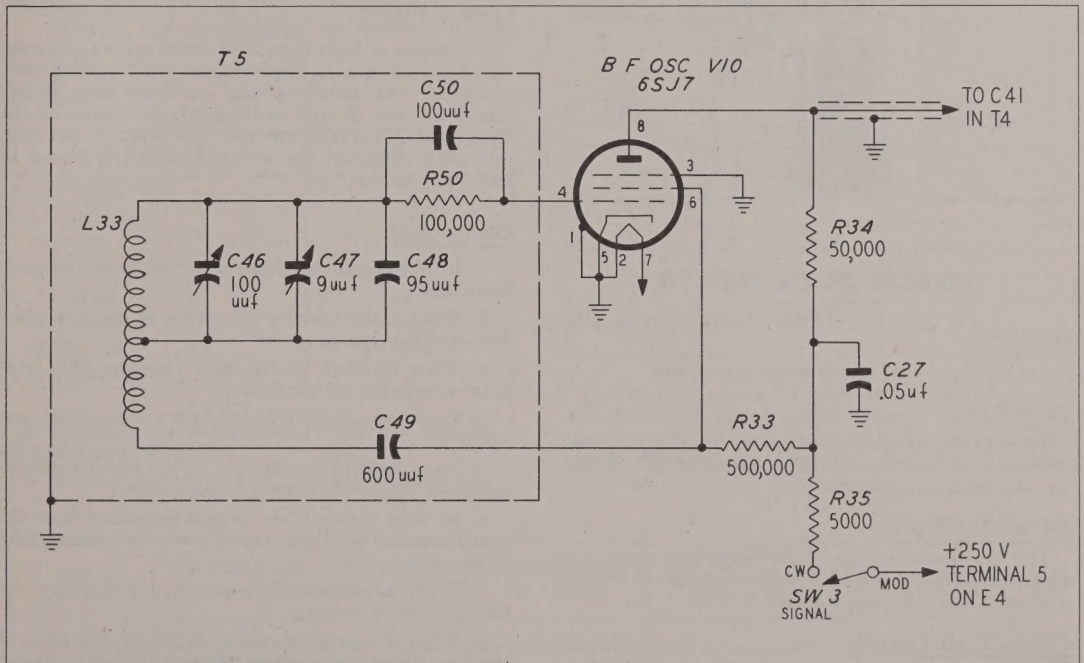
CIRCUIT ANALYSIS OF BEAT-FREQUENCY OSCILLATOR

The beat-frequency oscillator (BFO) is used during c-w operation, to provide an audible tone in the output of the receiver. This tone is adjustable by the BEAT OSCILLATOR control, located on the front panel. Figure 19 shows the simplified schematic of the beat-frequency oscillator.

The beat-frequency-oscillator stage uses a 6SJ7 sharp cut-off r-f pentode, V10, in an electron-coupled-type oscillator circuit, which provides good frequency stability under varying load conditions. The suppressor grid and cathode of V10 are connected directly to ground. A positive 250 volts from terminal 5 on terminal strip E4 is applied through the closed contacts of SW3, and the decoupling network consisting of resistor R35 and capacitor C27 to the screen grid through screen-grid load resistor R33, and to the plate through plate load resistor R34. Proper operating bias for the oscillator is obtained from the grid-leak combination consisting of capacitor C50 and resistor R50 connected between the grid and tank circuit. The oscillator tank circuit, located in shield can T5, consists of tapped coil L33, adjustable capacitor C46, fixed capacitor C48, and capacitor C47, the BEAT OSCILLATOR control. This tank circuit is connected between

the control grid, cathode, and screen grid of the tube in a modified-Hartley-type oscillator circuit. Regenerative feedback for oscillation is obtained by connecting the screen grid through coupling capacitor C49 to the other end of tank coil L33.

When the SIGNAL switch, SW3, is placed in CW position, it closes the circuit to the positive 250-volt supply for the plate and screen grid, thereby putting the stage in operation. The frequency of the oscillator is approximately 465 kc., and is adjustable from the front panel by means of the BEAT OSCILLATOR control which turns variable capacitor C47. This frequency, which is impressed on the grid of the tube, causes the plate current and, hence the plate voltage, to vary at the same rate. The output, which is taken from the plate of the tube, is fed through a shielded lead and coupling capacitor C41 to the tuned primary of L32, located in the plate circuit of the 3rd i-f amplifier, V7. This frequency combines with the intermediate frequency in the plate circuit of the 3rd i-f amplifier to produce a complex signal which contains the two original frequencies and the sum and difference frequencies. This complex signal is fed to the plate circuit of the 2nd detector and rectified. Since



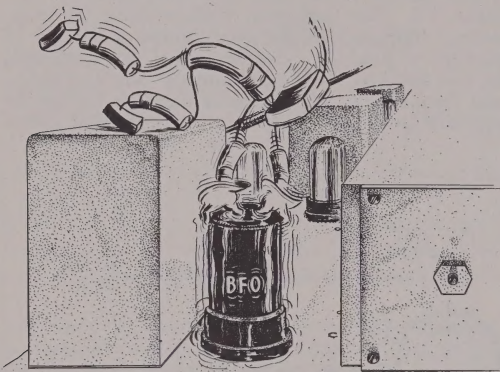
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Figure 19. Beat-Frequency-Oscillator Circuit

only the difference or "beat" frequency is in the audio range, it is the only frequency that is developed across the diode load and fed to the a-f section; all the other frequencies are filtered out. Any desired pitch is obtainable by varying the BFO frequency by means of the BEAT OSCILLATOR control on the front panel.

The beat-frequency oscillator is adjusted for proper operation by means of trimmer capacitor C46, located at the bottom of shield can T5. Proper alignment is accomplished by adjusting capacitor C46 for zero beat when the BEAT OSCILLATOR control knob is set at O.

A method of checking the beat-frequency-oscillator operation is to set the SIGNAL switch to CW, and tune in a strong c-w signal. A tone, the pitch of which depends upon the position of the BEAT OSCILLATOR control should be heard in the output of the receiver. If no tone is heard but the receiver operates properly for modulated signals, there is trouble in the beat-frequency-oscillator circuit. For this check the loud-speaker is designated as test point **H**.



LESSON PLAN No. 10

TIME ALLOTTED: ¾ HR.

SUBJECT

Circuit analysis of beat-frequency oscillator.

OBJECTIVE

To provide an understanding of the function and operation of the beat-frequency-oscillator circuit and its associated components.

INTRODUCTION

The beat-frequency oscillator is used to make c-w signals audible by providing a local signal to heterodyne with the incoming signal.

SUBJECT MATERIAL

1. Locate the beat-frequency oscillator on the functional block diagram, Wall Chart No. 1, and review the over-all function of the circuit in the receiver.

2. Locate the beat-frequency-oscillator circuit on the schematic diagram, Wall Chart No. 2.

3. Draw the simplified schematic (figure 19) on the blackboard.

4. Describe the type of tube and the kind of oscillator circuit used.

5. Explain how the control grid is biased.

6. Explain how the suppressor grid and cathode are connected.

7. Describe the components in the oscillator tank circuit, and explain how it is connected to the tube in a modified Hartley oscillator circuit.

8. Explain how the d-c operating potentials are applied to the plate and screen grid of the tube.

9. Explain how the beat-frequency oscillator is put into operation.

10. Explain how the operating frequency of the beat-frequency oscillator may be adjusted by means of the BEAT OSCILLATOR control.

11. Discuss the plate output circuit, and explain how the output voltage is fed to the plate circuit of the 3rd i-f amplifier.

12. Discuss the mixing action in the plate circuit of the 3rd i-f amplifier.

13. Discuss the action of the 2nd detector stage in detecting the "beat" frequency.

14. Discuss the adjustments provided for aligning the beat-frequency oscillator.

15. Explain the procedure used to check the operation of the beat-frequency oscillator.

CONCLUSIONS

To obtain a high degree of stability, an electron-coupled oscillator is employed as the beat-frequency oscillator. The beat-frequency oscillator may be adjusted for any desired audio pitch by means of the BEAT OSCILLATOR control. The stage is put into operation whenever the SIGNAL switch is placed in the CW position.

ORAL QUIZ

1. Briefly explain the function of the beat-frequency oscillator.

2. What is the primary advantage of using an electron-coupled-type oscillator?

3. What element in the tube develops the feedback voltage for the oscillator?

4. How does the SIGNAL switch put the stage into operation?

5. From which tube element of the beat-frequency-oscillator tube is the output voltage taken?

6. In what circuit is the output frequency from the beat-frequency oscillator mixed with the intermediate frequency?

7. What adjustment is provided for aligning the beat-frequency oscillator?

8. What test point is used to check the operation of the beat-frequency oscillator? How is this check made?

9. What control adjusts the pitch of the output signal?

10. What circuit is used to detect the "beat" frequency?

EXPERIMENT No. 8

TIME ALLOTTED: 1 HR.

SUBJECT

Beat-frequency oscillator.

OBJECTIVE

To become familiar with the method of troubleshooting and checking the beat-frequency oscillator.

EQUIPMENT REQUIRED

- 1 Radio Receiver BC-779-B (properly aligned).
- 1 Power-supply unit.
- 1 Interconnecting cable.
- 1 R-F signal generator.
- 1 Multimeter (20,000-ohms-per-volt sensitivity; 50, 250, and 500-volt ranges).
- 1 Loud-speaker or headset.

INSTRUCTIONS

Remove the dust cover and bottom plate from the receiver. Connect the receiver to the power supply unit, and plug the line cord into the a-c receptacle. Turn the OFF-ON switch ON, and allow the receiver to warm up. Do not make any adjustments other than those outlined in the procedure.

PROCEDURE

1. Connect the loud-speaker or headset to the receiver.
2. Adjust the receiver front-panel controls as follows:

CONTROL	POSITION
SENSITIVITY	10
AUDIO GAIN	6
SIGNAL	CW
AVC-MANUAL	AVC
LIMITER	OFF
CRYSTAL SELECTIVITY	OFF
SEND-REC	REC
BAND WIDTH	3

3. Check the over-all operation of the beat-frequency oscillator as follows:
 - a. Locate a strong c-w signal on any of the bands.

b. A tone should be heard in the receiver, and the pitch of this tone should vary as the BEAT OSCILLATOR control is turned.

4. Check the alignment of the beat-frequency oscillator as follows:

a. Turn on the signal generator, adjust it for the 465 kc., and turn off the modulation.

b. Connect the output lead of the signal generator through a .01-mf. capacitor to the grid cap of the 1st-detector tube, V3. Connect the ground lead to the receiver chassis.

c. Set the CRYSTAL SELECTIVITY switch to position 3, and adjust the signal-generator frequency until maximum deflection is obtained on the "S" meter. After the signal generator is adjusted, return the CRYSTAL SELECTIVITY switch to the OFF position.

d. Set the BEAT OSCILLATOR control to 0. If the beat-frequency oscillator is in perfect alignment no sound will be heard. The signal generator and the beat-frequency oscillator will be oscillating at the same frequency; therefore, no audible "beat" note will be produced. Turning the BEAT OSCILLATOR control to either side of 0 will produce a tone rising in pitch.

5. Using the voltmeter section of the multimeter, measure the voltages between the beat-frequency-oscillator tube-socket terminals and the chassis. Record the voltages in the following chart.

BEAT-FREQUENCY OSCILLATOR V10 (6SJ7)

PIN No.	VOLTAGE	FUNCTION
1		
2		
3		
4		
5		
6		
7		
8		

6. Turn the power OFF-ON switch OFF and, using the ohmmeter section of the multimeter, measure the resistances between the chassis and the beat-frequency-oscillator tube-socket terminals indicated in the following chart.

PIN No.	POSITION OF OPERATING CONTROL	RESISTANCE IN OHMS	CIRCUIT COMPONENTS MEASURED	TUBE ELEMENT
4				
6	SIGNAL switch to CW			
	SIGNAL switch to MOD			
8	SIGNAL switch to CW			
	SIGNAL switch to MOD			

7. After completing this portion of the experiment request the instructor to put a trouble in the beat-frequency-oscillator circuit. Use the procedure outlined in steps 1 through 4 to check the over-all operation of the circuit. Use the procedure in steps 5 and 6 to locate the faulty component.

CONCLUSIONS

1. What kind of tone should be heard in the output of the receiver when the BEAT OSCILLATOR control is varied either side of zero?

2. Why is there no audible tone in the output of the receiver when the signal-generator frequency is the same as the beat-frequency-oscillator frequency?

3. If capacitor C49 in the screen-grid circuit of V10 were to become defective (open circuit), how would the operation of the stage be affected?

4. What type of tube is used as the beat-frequency-oscillator tube?

5. If coupling capacitor C41 were to become defective (open circuit), how would the operation of the oscillator be affected?

LECTURE No. 11

CIRCUIT ANALYSIS OF AUDIO-FREQUENCY AMPLIFIERS

The audio-frequency-amplifier section is designed to give a maximum power output of 10 watts with high-fidelity reproduction. Figure 20 shows the schematic diagram of the audio-frequency-amplifier section.

The first stage of amplification, V13, is a class A voltage amplifier, employing a 6C5 medium-mu triode. The audio-frequency signal developed across the AUDIO GAIN control (R26), which is located in the second-detector diode-load circuit, is applied to the grid through coupling capacitor C24 and grid resistor R27. The amount of signal fed to the grid is determined by the position of the arm on the AUDIO GAIN control. The AUDIO GAIN control is also connected to two terminals marked "PHONO" at the rear of the receiver. The output of a record player may be fed to the grid of the first a-f amplifier through the AUDIO GAIN control by connecting the tone arm to the "PHONO" terminals. The other end of grid resistor R27 is returned to the negative 3-volt point on

the "C"-bias voltage divider to establish the proper bias for class A operation. The cathode is returned directly to ground. A positive 250 volts, obtained from terminal 5 on terminal strip E4, is applied to the plate through plate-load resistor R28. The plate current flow through plate-load resistor R28 develops the amplified audio voltage, which is fed to the a-f driver stage.

The a-f driver stage, V14, is designed to deliver a large signal current to the primary of the interstage audio-coupling transformer. A 6F6 pentode power amplifier is used as a triode in this stage by connecting the screen grid and plate together.

The audio signal voltage which is developed across plate-load resistor R28 in the 1st a-f amplifier stage is fed to the grid through coupling capacitor C25 and grid resistor R29. The grid is returned through grid resistor R29 to the negative 20-volt point on the "C"-bias voltage divider for class A operation. The cathode and suppressor grid, which are internally connected,

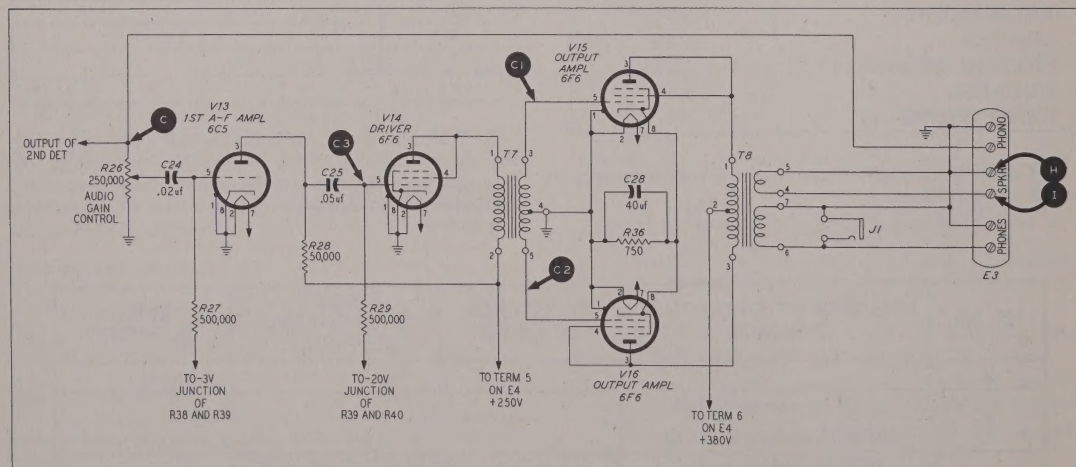
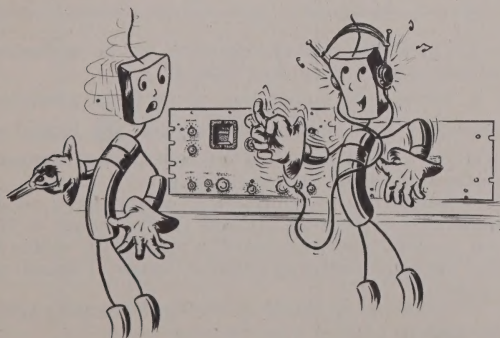


Figure 20. Audio-Frequency-Amplifier Circuits

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are returned directly to ground. A positive 250 volts, obtained from terminal 5 on terminal strip E4, is applied to the plate and screen grid through the primary of the interstage audio-coupling transformer, T7. The large signal current flowing in the plate circuit through the primary of T7 induces a voltage in the secondary, which drives the grids of the output amplifiers.

The output-amplifier circuit employs two 6F6 pentode power-amplifier tubes, V15 and V16, which are operated as triodes by connecting the screen and plate of each tube together. Both tubes are connected in push-pull and operate as a class AB2 amplifier. The opposite ends of the center-tapped secondary of the interstage audio-coupling transformer, T7, are connected to the grids of V15 and V16 and the center-tap is returned to ground. Both tubes are self-biased by the voltage developed across cathode resistor R36, which is bypassed by capacitor C28. A positive 380 volts, obtained from terminal 6 on terminal strip E4, is applied to the screen grids and plates of both tubes through the center-tap on the primary of output transformer T8. Transformer T8 has two secondary windings; one 600-ohm secondary is connected to the terminals marked "SPKR", and is capable of delivering all the power output of the amplifiers to a speaker; the other secondary is connected to the terminals marked "PHONES" at the rear of the receiver, and to the headphone jack located at the front of the receiver. The secondary used for headphones is capable of delivering about 3% of the output power into an 8000-ohm resistive load when the 600-ohm secondary is connected to a matched load. The turns ratio and resistance of the headphone secondary are such that the power delivered to any load between 8000 ohms and 80 ohms varies less than 6 db, and the power input to a 250-ohm load is but 2 db greater than that delivered to a 4000-ohm load. The audio voltage developed across the secondary winding of T7, which drives the grids of tubes V15 and V16, will at some levels overcome the bias applied to the grid and cause grid current to flow during a part of the input cycle. For power outputs up to approximately 3 watts no grid current flows and harmonic distortion is negligible; from 3 watts up to 10 watts the grid current increases steadily and a slight increase in distortion can be noticed.



In checking the audio-frequency-amplifier section for proper operation, test points **C**, **C1**, **C2**, and **C3** are employed. In localizing trouble to a section of the receiver, key test point **C** located at the input to the 1st a-f amplifier, V13, is used to check the over-all operation of the audio-frequency-amplifier section. When an audio-frequency signal is applied to test point **C**, a clear tone in the output of the receiver indicates that the audio-frequency-amplifier section is operating correctly. Whenever a check at test point **C** indicates improper operation, the other test points are used progressively to check the individual stages. Test point **C1** located at the grid of V15 and test point **C2** located at the grid of V16 check the operation of the push-pull amplifiers individually. When an audio-frequency signal is applied to these test points, a clear tone in the output of the receiver indicates that each of the push-pull amplifiers is operating correctly. When an audio-frequency signal is applied to test point **C3** located at the grid of the a-f driver, V14, a clear tone heard in the speaker indicates that this stage is operating correctly. Test point **C** is also used to check the 1st a-f amplifier. When the other audio stages are operating properly, an audio-frequency signal introduced at test point **C** should produce a clear tone in the output of the receiver, indicating that the 1st a-f amplifier is operating correctly.

LESSON PLAN No. 11

TIME ALLOTTED: 1 HR.

SUBJECT

Circuit analysis of audio-frequency-amplifiers.

OBJECTIVE

To provide an understanding of the function and operation of the audio-frequency-amplifier section and its associated components.

INTRODUCTION

A maximum of 10 watts of audio power can be obtained from the audio-frequency-amplifier section. The headphone output circuit is designed to vary less than 6 db for any load between 8000 ohms and 80 ohms.

SUBJECT MATERIAL

1. Locate the audio-frequency-amplifier section on the functional block diagram, Wall Chart No. 1. Review the over-all function of these circuits in the receiver.
2. Locate the audio-frequency-amplifier section on schematic diagram, Wall Chart No. 2.
3. Draw the simplified schematic (figure 20) of the 1st a-f amplifier, V13, on the blackboard.
4. Describe the type of tube used in the 1st a-f amplifier.
5. Discuss the coupling circuit between the 2nd detector and 1st a-f amplifier grid.
6. Explain how the tube is biased.
7. Explain how plate voltage is applied to the plate.

8. Explain how the output voltage is developed in the plate circuit.
9. Discuss the over-all purpose of the a-f driver stage.
10. State the type of tube used in the a-f driver stage.
11. Explain how the a-f output voltage is fed from the 1st a-f amplifier to the a-f driver grid.
12. Explain how the stage is biased.
13. Describe the cathode and suppressor-grid connections.
14. Explain how voltage is applied to the plate.
15. Discuss the plate output circuit, and explain how the output is developed.
16. Discuss the type of output-amplifier circuit employed.
17. Discuss the type of tube employed in the output amplifier, and explain how the two tubes are connected.
18. Discuss the coupling circuit between the a-f driver stage and the output amplifiers, and explain how the grids of the output amplifiers are connected.
19. Discuss the self-biasing arrangement in the cathode circuit.
20. Explain how plate voltage is applied to both tubes.
21. Discuss the primary and secondary windings of the output transformer; mention the various types of outputs that are available.
22. Discuss the procedure used to check the operation of the audio-frequency-amplifier section and explain the function of each of the test points.

CONCLUSIONS

The audio-frequency-amplifier section employs a 6C5 voltage-amplifier stage to feed a 6F6 driver stage which drives the output amplifiers, consisting of two 6F6's connected in push-pull. Up to 10 watts of power is available for driving a speaker, and 3% of this power is used to drive headphones. The operation of the circuits can be checked by using the test points as outlined in the lecture.

ORAL QUIZ

1. What is the maximum audio power output from the audio-frequency-amplifier section?
2. How may the audio power output be varied for any desired level?
3. What is the function of the a-f driver stage?
4. What component couples the a-f driver stage to the output amplifier?
5. What type of output-amplifier stage is used?
6. How many secondary windings are on the output transformer?
7. What is the impedance at the terminals marked "SPKR" at the rear of the receiver?
8. What is the class of operation of the output-amplifier stage?
9. What test point is used to check the over-all operation of the audio-frequency-amplifier section?
10. What test points are used for checking the individual circuits in the audio-frequency-amplifier section?

EXPERIMENT No. 9

TIME ALLOTTED: 2 HR.

SUBJECT

Audio-frequency amplifiers.

OBJECTIVE

To become familiar with the method of troubleshooting and checking the operation of the audio-frequency-amplifier section.

EQUIPMENT REQUIRED

- 1 Radio Receiver BC-779-B.
- 1 Power-supply unit.
- 1 Interconnecting cable.
- 1 Audio-frequency signal generator.
- 1 Multimeter (20,000-ohms-per-volt sensitivity; 50, 250, and 500-volt ranges).
- 1 Loud-speaker or headset.

INSTRUCTIONS

Remove the dust cover and bottom plate from the receiver. Connect the receiver to the power-supply unit and plug the line cord into the a-c receptacle. Turn the OFF-ON switch ON and allow the receiver to warm up. Do not make any adjustments other than those outlined in the procedure.

PROCEDURE

1. Connect the loud-speaker or headset to the receiver.

2. Adjust the front-panel controls on the receiver as follows:

CONTROL	POSITION
SENSITIVITY	10
AUDIO GAIN	6
SIGNAL	MOD
AVC-MANUAL	AVC
LIMITER	OFF
CRYSTAL SELECTIVITY	OFF
SEND-REC	REC
BAND WIDTH	3

3. Check the over-all operation of the audio-frequency amplifier section as follows:

a. Connect the output lead of the signal generator through a .1-mf. capacitor to test point **c** located at the high side of the AUDIO GAIN control. Connect the ground lead to the receiver chassis.

b. Adjust the signal-generator output for a weak signal and advance the AUDIO GAIN control to 10.

c. A loud, clear tone heard in the speaker indicates that the audio-frequency-amplifier section is operating correctly.

4. Check the operation of V15 in the output-amplifier stage as follows:

a. Connect the signal generator, in the same manner as outlined in step 3a, to test point **(c₁)** located at the grid (pin 5) of V15.

b. Adjust the signal-generator output for a slightly stronger signal.

c. A clear tone in the loud-speaker indicates that the stage is operating correctly.

5. The operation of V16 in the output-amplifier stage may be checked in the same manner as outlined in step 4. The signal generator should be connected to test point **(c₂)** located at the grid (pin 5) of V16.

6. Check the operation of the a-f driver stage, V14, as follows:

a. Connect the signal generator, in the same manner as outlined in step 3a, to test point **(c₃)** located at the grid (pin 5) of V14.

b. A louder tone in the loud-speaker than in step 5 indicates that the a-f driver stage is operating correctly.

7. Check the operation of the 1st a-f amplifier, V13, as follows:

a. Connect the signal generator to test point **(c)**, as outlined in step 3a.

b. A louder tone in the loud-speaker than in step 6 indicates that the 1st a-f amplifier, V13, is operating correctly.

8. Using the voltmeter section of the multimeter, measure the voltages at the tube socket terminals of the 1st a-f amplifier, a-f driver and output amplifiers. Record the voltages in the following chart.

1ST A-F AMPLIFIER V13 (6C5)

PIN No.	VOLTAGE	FUNCTION
1		
2		
3		
4		
5		
6		
7		
8		

A-F DRIVER V14 (6F6)

1		
2		
3		
4		
5		
6		
7		
8		

OUTPUT AMPLIFIER V15 (6F6)

1		
2		
3		
4		
5		
6		
7		
8		

OUTPUT AMPLIFIER V16 (6F6)

PIN No.	VOLTAGE	FUNCTION
1		
2		
3		
4		
5		
6		
7		
8		

9. Turn the power OFF-ON switch OFF and, using the ohmmeter section of the multimeter, measure the resistances between the chassis and the tube-socket terminals indicated in the following chart.

1ST A-F AMPLIFIER V13 (6C5)

PIN No.	RESISTANCE IN OHMS	CIRCUIT COMPONENTS MEASURED
3		
5		

A-F DRIVER V14 (6F6)

3 or 4		
5		

10. After completing this portion of the experiment, request the instructor to put a trouble in the audio-frequency-amplifier section. Use the procedure outlined in steps 1 through 7 to check the operation of the individual circuits. Use the procedure in steps 8 and 9 to locate the faulty component.

CONCLUSIONS

1. Where is test point **(c)** located?
2. If C25, located between the 1st a-f amplifier and the a-f driver, were to become defective (short circuit), what voltage would be measured at the grid of the a-f driver tube?
3. If one of the output-amplifier tubes were to become defective (open filament), how would the output of the receiver be affected?
4. What circuit would be defective if no signal were heard in the output of the receiver when the signal generator is connected to test point **(c₁)**?
5. If capacitor C28 in the cathode circuit of the output amplifiers were to become defective (short circuit), what voltage would be read at the cathode?

LECTURE No. 12

CIRCUIT ANALYSIS OF POWER-SUPPLY UNITS

The receiver power supply, which furnishes filament, screen, plate, and grid-bias voltages, is a separate, external unit. The advantages in this arrangement are: a minimum of hum is introduced into the receiver; the over-all temperature rise is reduced; and better stability is obtained.

Any one of three power-supply units may be used with the receiver; these are the RA-74-C, RA-84-B, and RA-94-A. All are identical, except for variations in the power transformers. The primary of the power transformer used in the RA-94-A has two taps for connection to 105-volt or 230-volt power lines. Power Supply Unit RA-84-B has three taps on the primary of its power transformer, for connection to 105, 115, and 125-volt power lines. The RA-74-C has eight taps on the primary of its power transformer, for connection to 95, 105, 117, 130, 190, 210, 234, or 260-volt power lines.

The circuit, as shown in figure 21, is the schematic diagram of the RA-94-A, and is the same for all three power-supply units, except for the wiring of the primary of the power transformer. The power-supply unit is connected to the receiver through an interconnecting cable, which connects each of the terminals (except terminal 10) on terminal strip E1 to the terminal on terminal strip E4, in the receiver, which bears the same number. The power-supply unit is turned on by the ON-OFF switch, located on the re-

ceiver front panel. Closing this switch connects terminals 8 and 9 together, thereby completing the circuit between the primary winding on the transformer and the input power line. The primary circuit is fused by a 250-volt, 2-ampere fuse, located at the rear of the power-supply unit.

The power transformer, T3, has one center-tapped, high-voltage secondary winding and three low-voltage secondary windings. The high-voltage secondary and two low-voltage secondaries are utilized in the power-supply circuits, whereas terminals 1 and 2 on the power transformer, the 6.3-volt secondary winding, are connected to terminals 1 and 2 on terminal strip E1, to supply the filament voltage for all the tubes in the receiver.

Two rectifier circuits are used; one high-voltage rectifier supplies plate and screen voltage for the receiver, and one "C"-bias rectifier supplies grid bias voltage.

The high-voltage rectifier is a full-wave rectifier employing a 5Z3 tube, V1. Filament voltage for the tube is obtained from the 5-volt secondary winding, terminals 5 and 6, on the power transformer. The plates are connected to the entire high-voltage secondary winding, at terminals 7 and 10, of the power transformer. Terminal 8 on the power transformer, the center tap on the secondary, is returned directly to ground. The rectifier positive voltage, which appears between the

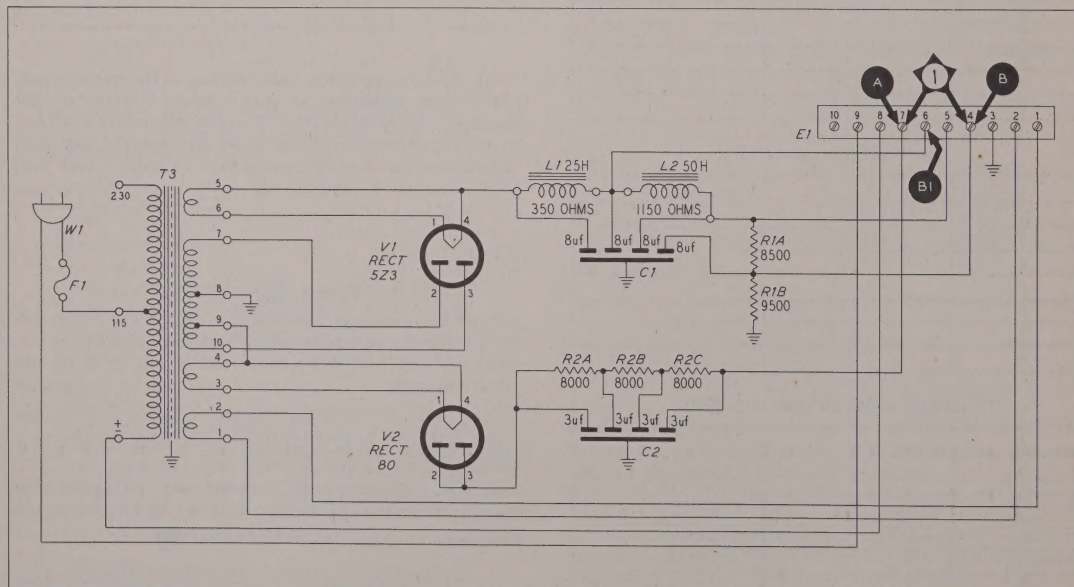


Figure 21. Power-Supply Circuits

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filament and ground, is filtered by the combined action of the first filter choke, L1, and the first two 8-mf. sections of filter capacitor C1. The output of this filter section is connected to terminal 6 on terminal strip E1, and provides 380 volts for the plates of the audio output-amplifier tubes, V15 and V16, in the receiver. Further filtering of the rectified voltage by the second filter choke, L2, and another 8-mf. section of condenser C1, drops the voltage to 250 volts. The output of this section is connected to terminal 5 on terminal strip E1, to provide plate voltage for the 1st a-f amplifier, V13, 2nd i-f amplifier, V6, and 1st i-f amplifier, V5; also plate and screen voltage for the a-f driver, V14, a-v-c amplifier, V11, beat-frequency oscillator, V10, 3rd i-f amplifier, V7, and the h-f oscillator, V4. Approximately 100 volts is obtained from the tap on the bleeder resistor, R1, and filtered by the remaining 8-mf. section of capacitor C1. The output of this section is connected to terminal 4 on terminal strip E1, to provide screen voltage for the 2nd i-f amplifier, V6, 1st i-f amplifier, V5, 2nd r-f amplifier, V2, and 1st r-f amplifier, V1.

The "C"-bias rectifier, V2, which supplies bias voltage for the receiver, employs an 80 tube, which is a duo-diode, connected for half-wave rectification. Filament voltage is obtained from the 5-volt filament winding at terminals 3 and 4 on the power transformer. The filament of the tube is connected to terminal 9, on the high-voltage secondary winding, which is a tap between terminal 8 and terminal 10. The a-c voltage that appears between terminal 9 and terminal 8 on the secondary is rectified by V2, and the negative output which appears between the plate and ground is filtered by resistor R2 and capacitor C2. The output of the filter is 50 volts negative, with respect to ground, and is connected to terminal 7 on terminal strip E1, to provide "C"-bias voltage for the voltage-divider network in the receiver.

The operation of the power supply is checked by using four test points. Major test point **1**, located between terminals 4 and 7, on terminal strip E1, checks the entire power supply: if a meter with a 20,000-ohms-per-volt sensitivity is connected at this point, a reading of approximately +170 volts indicates proper operation of the high-voltage and "C"-bias rectifiers. The "C"-bias rectifier is checked by reading the voltage between key test point **A**, located at terminal 7 on terminal strip E1, and ground; a reading of approximately -60 volts indicates that the rectifier is operating correctly. A reading on the meter of approximately +110 volts between key test point **B**, located at terminal 4 on terminal strip E1, and ground indicates that the high-voltage rectifier and associated filter circuit is operating correctly. If the reading at key test point **B** is abnormal, the functioning of the high-voltage rectifier should be thoroughly checked with the receiver disconnected. Extreme caution should be used, due to the high voltages involved. The a-c power cord should be disconnected from the power source, and the interconnecting cable between the power supply and receiver should be disconnected. A jumper wire should be connected between terminals 8 and 9 on terminal strip E1. The operation of the rectifier tube V1, transformer T3, choke L1, and the first two 8-mf. sections of capacitor C1 may be determined by reading the voltage between terminal 6 and

ground at secondary test point **B1**. A reading of approximately +500 volts indicates that the circuit is operating correctly. The operation of choke L2, capacitor C1, and resistor R1 may be checked by reading the voltage at test point **B** again. A reading of +240 volts indicates that this section is operating correctly.

LESSON PLAN No. 12

TIME ALLOTTED: ¾ HR.

SUBJECT

Circuit analysis of power-supply units.

OBJECTIVE

To provide an understanding of the function and operation of the power-supply units and their associated components.

INTRODUCTION

Three power-supply units are available for use with the receiver. Each unit is an extra-heavy-duty supply, designed to furnish filament, screen, plate and grid-bias voltages.

SUBJECT MATERIAL

1. Locate the power-supply unit on the functional block diagram, Wall Chart No. 1.
2. Locate the power-supply unit on the schematic diagram, Wall Chart No. 2.
3. Discuss the over-all purpose of the power-supply unit, and the advantages obtained by having a separate unit.
4. Discuss the differences between the three power-supply units available.
5. Draw figure 21 on the blackboard.
6. Discuss the primary circuit of the power transformer.
7. Describe the manner in which the unit is turned on.
8. Describe the secondary windings on the power transformer, and the over-all purpose of each winding.
9. Discuss the over-all purpose of using two rectifiers.
10. Describe the type of high-voltage rectifier used; mention the type of tube employed.
11. Discuss the manner in which the plates of the high-voltage rectifier are connected to the high-voltage secondary winding.
12. Discuss the 380-volt output circuit of the high-voltage rectifier.
13. Discuss the 250-volt output circuit of the high-voltage rectifier.
14. Discuss the 100-volt output circuit of the high-voltage rectifier.
15. Describe the type of "C"-bias rectifier circuit used; mention the type of tube employed, and the manner in which it is connected.
16. Describe the manner in which filaments of the "C"-bias rectifier are connected to the high-voltage secondary winding.
17. Discuss the type of voltage available at the output of the "C"-bias rectifier, and the manner in which it is filtered.
18. Discuss the procedure used to check the over-all operation of the power-supply unit, and the function of each of the test points used.

CONCLUSIONS

The high-voltage rectifier in the power supply is a 5Z3, connected in a full-wave circuit, with a two-section filter, and supplies 380, 250, and 100 volts for the tubes. Grid bias for the receiver is supplied by an 80 tube, operating from a tap on the high-voltage secondary in a half-wave-rectifier circuit. By using major test point  , key test points  and  , and secondary test point  , the entire power supply may be checked.

ORAL QUIZ

1. What type of rectifier circuit is used as the high-voltage rectifier?
2. What is the primary difference between the three power-supply units?

3. How many secondaries does the power transformer have?

4. What voltages are supplied by the high-voltage rectifier?

5. What type of "C"-bias rectifier is used?

6. What voltage is supplied by the "C"-bias rectifier?

7. What test point is used to check the over-all functioning of the entire power supply?

8. What size fuse is used in the power supply?

9. How does the OFF-ON switch turn on the power-supply unit?

10. What are three advantages of using an external power supply?

EXPERIMENT No. 10

TIME ALLOTTED: 1½ HR.

SUBJECT

Power supply unit.

OBJECTIVE

To become familiar with the method used to trouble-shoot and check the operation of the power-supply unit.

EQUIPMENT REQUIRED

- 1 Radio Receiver BC-779-B.
- 1 Power-supply unit.
- 1 Interconnecting cable.
- 1 Multimeter (20,000-ohms-per-volt sensitivity; 50, 250, 500, and 1000-volt ranges).

tacle. Turn the OFF-ON switch ON and allow the receiver to warm up. Do not make any adjustments other than those outlined in the procedure.

PROCEDURE

1. Check the operation of the power supply by measuring the voltages on terminal board E1, at the test points indicated in the chart below. Record the readings in the chart.

2. Disconnect the a-c power cord from the power source, and remove the interconnecting cable from the terminal board at the rear of the power supply. Connect a jumper wire between terminals 8 and 9 of

Test Point	Voltmeter Connection	Voltage	Function
	Connect positive lead of voltmeter (0 — 250-volt d-c range) to terminal 4; connect negative lead to terminal 7.		
	Connect positive lead of voltmeter (0 — 250-volt, d-c range) to terminal 7; connect negative lead to chassis.		
	Connect positive lead of voltmeter (0 — 250-volt, d-c range) to terminal 4; connect negative lead to chassis.		

INSTRUCTIONS

Remove the dust cover and bottom plate from the power-supply unit. Connect the receiver to the power-supply unit and plug the line cord into the a-c recep-

terminal board E1. Check the operation of the high-voltage rectifier by measuring the voltages at the test points indicated in the chart below. Record the readings in the chart. CAUTION: HIGH VOLTAGE!

Test Point	Voltmeter Connection	Voltage	Function
B1	Connect positive lead of voltmeter (0 — 1000-volt, d-c range) to terminal 6; connect negative lead to chassis.		
B	Connect positive lead of voltmeter (0 — 250-volt, d-c range) to terminal 4; connect negative lead to chassis.		

3. Using the ohmmeter section of the multimeter measure the resistances at the high-voltage-rectifier and "C"-bias-rectifier socket terminals and record the information in the following chart.

CONCLUSIONS

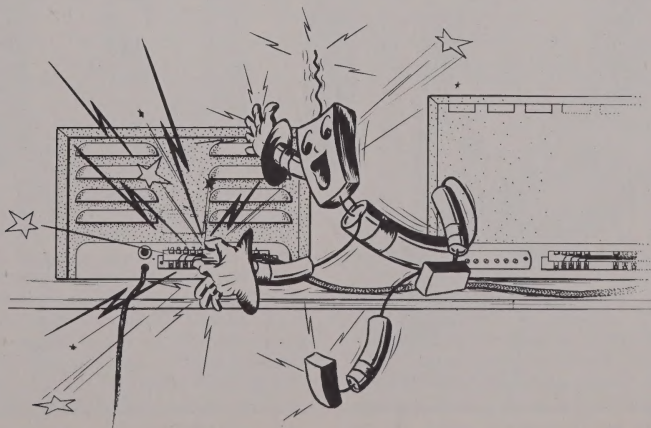
1. What is the purpose of major test point **1** ?
2. What test point is used to check the over-all function of the "C"-bias rectifier?

HIGH-VOLTAGE RECTIFIER V1(5Z3)

PIN No.	RESISTANCE IN OHMS	CIRCUIT COMPONENTS MEASURED	TUBE ELEMENT
2			
3			
1 or 4			
"C"-BIAS RECTIFIER V2 (80)			
2 or 3			
1 or 4			

4. After completing this portion of the experiment, request the instructor to put a trouble in the power-supply unit. Use the procedure outlined in steps 1 and 2 to check the operation of the individual circuits. Use the procedure in step 3 to locate the faulty component.

3. If an improper voltage is measured at test point **B**, what test points should be used to check the individual circuits in the high-voltage rectifier?
4. Why is the voltage at test point **B** higher with the receiver disconnected?
5. What test point indicates trouble in choke L1?



LECTURE No. 13

ALIGNMENT AND ADJUSTMENT

In a receiver as complex as the BC-779-B, there are many alignment adjustments which must be accurately set to ensure the best possible performance of all the circuits. Proper alignment is one of the primary factors that determine the over-all sensitivity and selectivity of the receiver. The circuits that are aligned are in the r-f section, i-f section, a-v-c section, and beat-frequency oscillator. Whenever the selectivity or sensitivity (or both) appear to be below normal, and all the tubes check good, the alignment of these circuits should be checked, as described in the individual experiments for these sections.

A number of test instruments and tools are necessary when making the alignment adjustments. An accurately calibrated signal generator which has provisions for modulation is required. The frequency range of the signal generator must include the i. f. (465 kc.), and cover all the bands of the receiver. A 400-cycle output meter with a resistance of more than 500 ohms and having a range of 15 to 30 volts is needed. To vary the adjustment screws, an insulated

screw driver 9/64" wide and .025" thick at the bit is required.

Connect the output meter to the terminals marked "SPKR" at the rear of the receiver. Before any alignment is attempted the receiver should be warmed up for at least 15 minutes. Set the front-panel controls as follows:

CONTROL	POSITION
SENSITIVITY	6
AVC-MANUAL	MANUAL
SIGNAL	MOD
SEND-REC	REC
BAND SWITCH	2.5-5.0
AUDIO GAIN	6
CRYSTAL SELECTIVITY	OFF
PHASING	Arrow
BAND WIDTH	3
BAND SPREAD	100

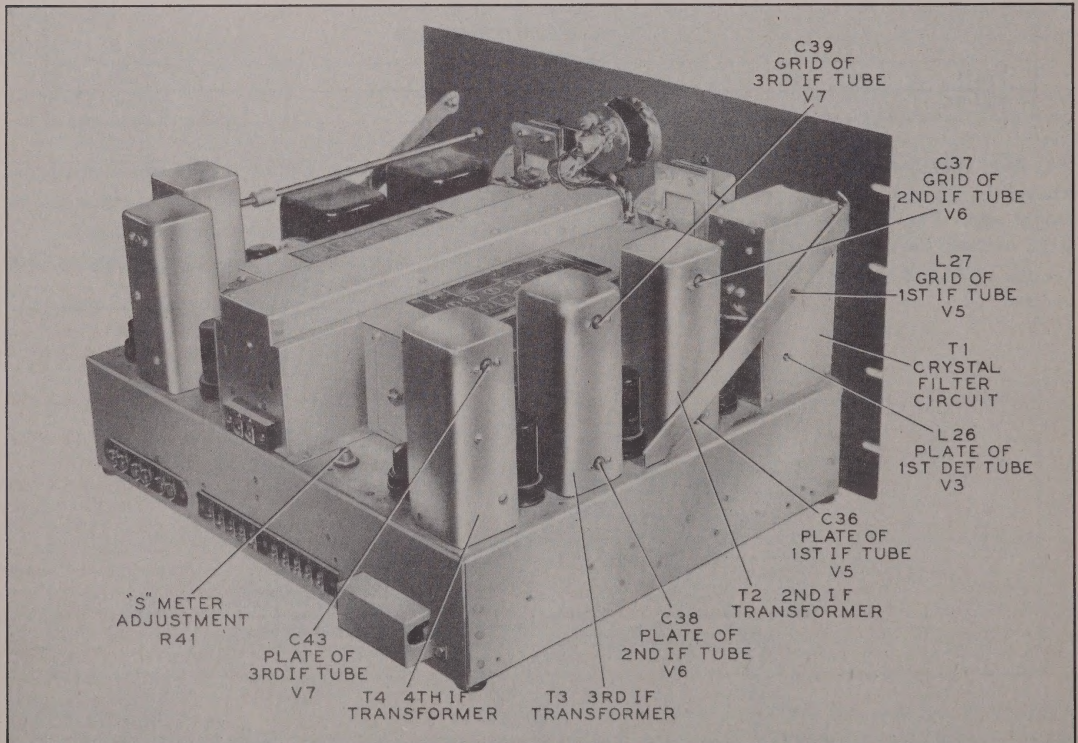


Figure 22. Locations of I-F Alignment Adjustments

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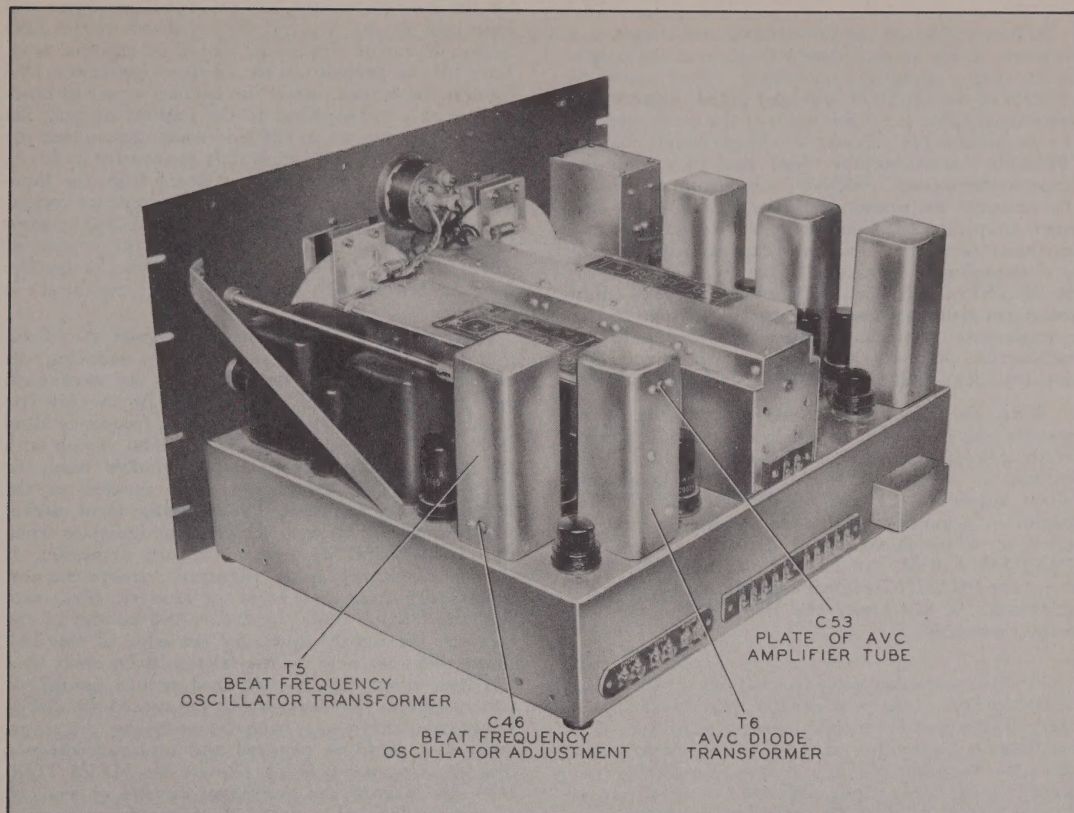


Figure 23. Locations of A-V-C and B-F-O Alignment Adjustments

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The alignment of the i-f section must be accurate before the alignment is made in the other sections. To align the i-f section, adjust the signal generator for 465 kc., turn on the modulation, and connect the output lead through a 100-mmf. fixed capacitor to the grid of the 3rd i-f amplifier (pin 4 of V7). Connect the ground lead of the signal generator to the chassis. Adjust the signal-generator output for a half-scale reading on the output meter. Adjust the trimmer capacitor of T4 in the 3rd i-f stage for maximum output-meter reading. See figure 22. While making the adjustments, reduce the output of the signal generator as necessary, to keep the meter reading at half-scale. Connect the signal generator to the 2nd i-f grid, and adjust the grid and plate trimmers of T3 for maximum output-meter reading, in the same manner as described for T4 in the 3rd i-f adjustment. Connect the signal generator to the grid of the 1st i-f amplifier, and align the trimmers of T2 in the same manner. Then connect signal generator to the signal grid (grid cap) on the first detector V3, and adjust the coupling circuit to the crystal filter as follows: Without tuning in an external station, set the MAIN TUNING dial near the 2.5 mc. end of the band. This setting provides enough impedance in the grid circuit

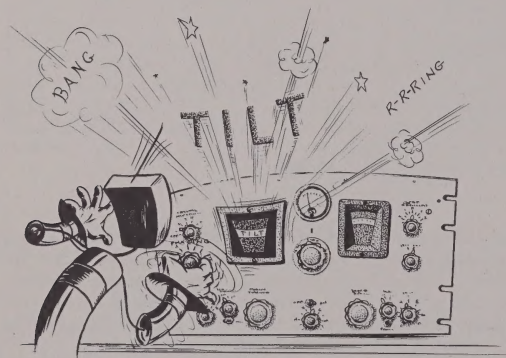
at the signal-generator frequency to prevent shorting out the signal. Vary the lower adjustment screw on shield can T1 for maximum output-meter reading. Turning this screw varies the inductance in the primary and secondary of L26 by changing the position of a powdered-iron core within the coils.

When the above procedure is completed, set the CRYSTAL-SELECTIVITY switch to 3, the AVC-MANUAL switch to AVC, and the SENSITIVITY control to 10. With the signal generator still connected to the grid of the 1st detector, adjust its frequency around 465 kc., with the modulation turned off, until maximum deflection is obtained on the "S" meter. The adjustment of the signal generator in this manner is necessary in order to determine the exact frequency of the particular crystal used in the receiver. When the maximum deflection on the "S" meter is obtained, lock the signal-generator dial at that frequency, if possible. Return the CRYSTAL SELECTIVITY control to the OFF position, and AVC-MANUAL switch to MANUAL. Turn on the modulation of the signal generator and adjust the signal-generator output until a half-scale reading of 5 to 10 volts is obtained on the output meter. Repeat the complete alignment of the i-f section, with

the signal generator connected to the grid of the 1st detector.

To properly adjust the crystal-filter load circuit, it is necessary to use an oscilloscope in place of the output meter, and a frequency-modulated signal generator in place of the amplitude-modulated one. Connect the vertical-amplifier input terminals of the oscilloscope to the output of the receiver at the terminals marked "PHONO," attaching the "hot" lead of the oscilloscope to the second "PHONO" screw from the end of the terminal strip, and the ground lead to the first screw from the end. Connect the output of the signal generator through a 100-mmfd. capacitor (or larger) to the signal grid (grid cap) of the 1st detector. With the CRYSTAL SELECTIVITY switch at OFF, adjust the signal-generator frequency to 465 kc. to produce a single-peak resonance curve on the screen of the oscilloscope. Note the width of the curve, and then turn the CRYSTAL SELECTIVITY switch to position

1. With the PHASING control set to the arrow position, the curve should remain symmetrical but the width should decrease about one-third, indicating an increase in selectivity. If this condition is not obtained, adjust coil L27 and the PHASING control for maximum symmetry of the curve, by varying the upper screw on shield can of T1 while rocking the PHASING control. At the point of maximum symmetry the PHASING control knob should point to the arrowhead; if not, reset the PHASING knob and pointer assembly.

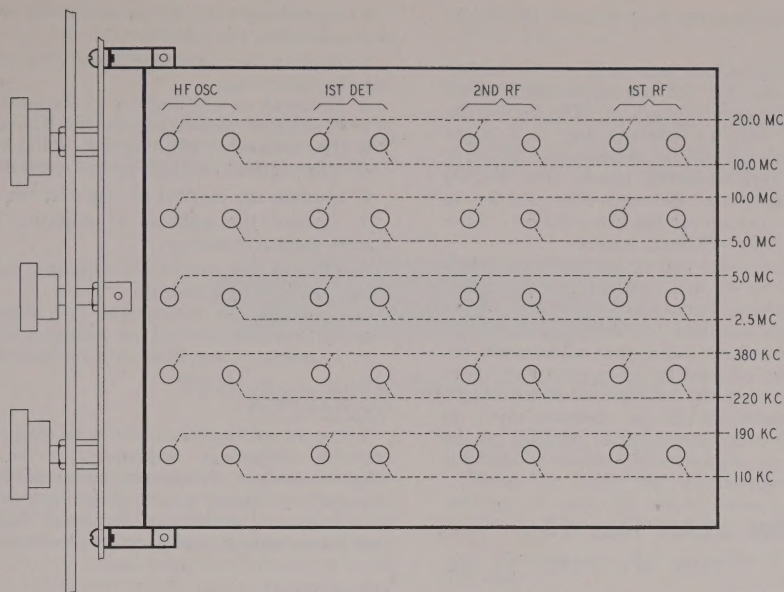


After the i-f section has been properly aligned the a-v-c section should be aligned next. Since the signal used by the a-v-c amplifier in the a-v-c section is obtained from the 3rd i-f amplifier grid circuit, the amplitude-modulated generator may be connected to the grid of the 1st-detector tube. The output meter is connected to the "SPKR" terminals at the rear of the receiver chassis. Adjust the AUDIO GAIN control to 0, and set the AVC-MANUAL switch to AVC, putting the "S" meter in the circuit. Set the SENSITIVITY control for maximum sensitivity, and adjust the signal-generator output for an output-meter reading near half-scale (10-15 volts). Adjust the trimmer capacitor in shield can T6 for minimum output-meter reading. The "S"-meter reading should peak at the same time that the output-meter reading dips.

With the receiver controls in the same positions as for the a-v-c alignment, and the signal generator still connected to the grid of the 1st detector, the BFO circuit, if out of alignment, should be adjusted next. Turn off the modulation on the signal generator. Disconnect the output meter, and connect a pair of headphones or a loud-speaker to the receiver output. Set the SIGNAL switch to CW and make certain that the BEAT OSCILLATOR control is set exactly at 0. At this setting no tone should be heard from the loud-speaker. If a tone is heard, the beat-frequency oscillator needs to be adjusted. This is accomplished by varying the trimmer capacitor, C46, near the bottom of shield can T5, until the tone in the phones or speaker is at the lowest pitch or until no tone (zero beat) is obtained.

After the i-f section is accurately aligned, the r-f section should be checked next. Before checking the electrical alignment of the r-f section the mechanical dial alignment should be checked. At the low-frequency end of the dial scale for each frequency band there is an alignment marker which must line up with the hairline indicator on the dial window when the MAIN TUNING capacitor is fully meshed; at the high-frequency end there is another alignment marker which must line up with the hair line indicator when the MAIN TUNING capacitor is fully unmeshed. If the dial needs mechanical alignment; remove the dust cover and bottom plate from the receiver. Make sure that the friction disks, located at the bottom of the receiver, are tightly squeezing the edge of the dial. These disks are held on the friction drive shaft by a hex nut, which can be tightened with a wrench or pair of pliers. If a heavy shock has caused the dial to jump completely out from between the disks, the outer disk must be removed and replaced with the dial in its proper position. Rotate the MAIN TUNING dial toward the low-frequency end of any one of the bands until it cannot be rotated any further. Loosen the two setscrews in the dial collar which couples the dial to the capacitor drive shaft. This permits moving the dial without moving the capacitors. Adjust the dial until the indicator hairline coincides with the alignment mark on the low-frequency end of the band. Make sure that capacitors are fully meshed, and then tighten the two setscrews on the dial collar. Check the dial to make sure that it is mechanically aligned on each band.

After the mechanical dial alignment is completed, the electrical alignment of the r-f section should be checked as outlined in Experiment No. 4. If the MAIN TUNING dial is found to be incorrectly calibrated, the h-f oscillator should be aligned before the alignment of the r-f amplifier and 1st-detector stages is attempted. For proper dial calibration, it is necessary that the h-f oscillator frequency be exactly 465 kc. (the intermediate frequency) above that of the incoming signal as indicated on the MAIN TUNING dial. For example, when the MAIN TUNING dial is adjusted for an incoming signal of 5 mc., the h-f oscillator must be oscillating at exactly 5.465 mc. to produce the correct i-f signal. For making the oscillator frequency adjustment, an accurately calibrated signal generator is required. If the accuracy of the signal generator is doubtful, it should be calibrated with a known frequency standard. The output of the signal generator should be unmodulated.



TP-9892

Figure 24. Tuning Unit, Showing Locations of Adjustments

Turn the SIGNAL switch on the receiver to CW. Set the BEAT OSCILLATOR control to 0, the AVC-MANUAL switch to MANUAL, the AUDIO GAIN to 10, and the BAND WIDTH to 16. Connect the signal generator to the antenna terminals; if sufficient output is not obtained, the signal generator may be connected to the grid (grid cap) of the 1st detector, through a 100-mmF. capacitor. A headset or loud-speaker should be connected to the receiver.

The accuracy of the dial for each frequency band is adjusted by aligning the proper oscillator tank circuit at the low-frequency and high-frequency ends of the dial. To make the tuning adjustments accessible, the receiver should be placed on its side. See figure 24. Assuming that the 2.5—5.0-mc. band needs adjustment, the method of alignment, which is applicable to any band, is as follows: Adjust the signal generator for 5.0 mc., and tune the MAIN TUNING dial until zero beat is obtained in the loud-speaker or headset. If the MAIN TUNING dial is not on the 5.0-mc. calibration line at the zero-beat point, vary the dial in the direction of the 5.0-mc. line until a high-pitched tone is heard in the loudspeaker. Locate the 5.0-mc. trimmer-capacitor adjusting screw and vary it until zero beat is again obtained. Again tune the MAIN TUNING dial toward the 5.0-mc. calibration line until a high-pitched tone is heard, and make a further adjustment of the trimmer capacitor for zero beat. Repeat this process as many times as necessary until zero beat is obtained exactly at the 5.0 mc. calibration line. Never vary the dial beyond the audible range of beat frequency. Using a procedure similar to that given for the high-frequency end of the band, align the h-f oscillator at the 2.5-mc. low-frequency end by varying the inductance adjustment. Due to the fact that the low-frequency adjustment also affects the high-fre-

quency end of the band, the dial calibration at 5.0 mc. should be checked. Usually a number of adjustments at the low-frequency and high-frequency ends of each band are required before exact calibration is obtained.

For maximum efficiency in the reception of weak signals, with low receiver noise level and a high image-rejection ratio, the antenna, r-f amplifiers and 1st-detector circuits must track accurately with the h-f oscillator. For all frequencies of reception these circuits must resonate 465 kc. lower than the frequency of the h-f oscillator circuit. The best results will be obtained if the antenna, r-f amplifier, and 1st-detector circuits for a given band are aligned immediately after the h-f oscillator is adjusted. With the signal-generator output unmodulated, leave the SIGNAL switch in the CW position, and set the BEAT OSCILLATOR control to 2 (either side of zero), to produce 400-cycle tone in the output of the receiver. Connect the output of the signal generator to the antenna terminals through a resistance of 100 ohms, including the output resistance of the signal generator, or, to avoid removing the antenna system, loosely couple the output of the signal generator to some point on the antenna system. Again assuming that the 2.5—5.0-mc. band is to be aligned, the following alignment procedure, which is applicable to all bands, should be used. Set the MAIN TUNING dial to 5.0 mc. (BAND SPREAD dial to 100), and adjust the frequency of the signal generator for maximum deflection on the output meter. Adjust the SENSITIVITY control to produce a half-scale reading on the output meter. Starting with the trimmer capacitors for the 1st detector, shown in figure 24, and proceeding with the trimmer capacitors for the 2nd r-f and 1st r-f circuits, in the same manner, vary each adjustment for maximum output on the output meter. Adjust the SENSITIVITY con-

trol, as necessary, to keep the output-meter reading at half-scale.

NOTE: It is very important, especially on the higher frequency bands, that the tuning of the receiver be checked after each adjustment. The h-f oscillator frequency may be affected due to a slight interaction between the 1st detector and h-f oscillator on the high-frequency bands. The BAND SPREAD control may be used as a vernier in checking the tuning on the 2.5—5.0-mc., 5.0—10.0-mc., and 10.0—20.0-mc. bands.

After the high-frequency end of the band is aligned, turn the main dial to 2.5 mc., and readjust the signal generator for maximum output-meter reading. Using the same procedure outlined for the 5.0-mc. end of the band, adjust the three inductance adjustments for the 1st-detector, 2nd r-f, and 1st r-f circuits; see figure 24. Due to interaction, the low-frequency and high-frequency adjustments should be repeated until no further improvement in output-meter reading can be obtained. The same alignment procedure is used for all bands of the receiver.

LESSON PLAN No. 13

TIME ALLOTTED: 1½ HR.

SUBJECT

Alignment and adjustment.

OBJECTIVE

To provide an understanding of the alignment and adjustment procedure for the receiver.

INTRODUCTION

Proper alignment is one of the primary factors that determine the over-all sensitivity and selectivity of the receiver. Accurate alignment will ensure the best possible performance of all the circuits.

SUBJECT MATERIAL

1. Explain the purpose of aligning the receiver and the effects of improper alignment.
2. Discuss the test instruments required for alignment.
 - a. Type of signal generator.
 - b. Type of output meter.
 - c. Type of screw driver.
3. Give the proper settings of the front-panel controls.

4. Describe the manner in which the test equipment is connected to the receiver.

5. Explain the alignment of the i-f section, mentioning the following:

- a. Necessity of aligning the i-f section first.
 - b. Manner of connecting the test equipment.
 - c. The method of aligning the i-f amplifiers.
 - d. The method of aligning the crystal-filter circuit.
6. Explain the method of aligning the a-v-c section.
7. Explain the method of aligning the beat-frequency-oscillator section.
8. Explain the method of aligning the r-f section, mentioning the following:
- a. Checking the mechanical dial alignment.
 - b. Dial calibration and h-f oscillator alignment.
 - c. Antenna, r-f amplifier, and 1st-detector alignment.

CONCLUSIONS

Accurate test equipment must be used when making receiver alignment adjustments. An improperly aligned receiver, which may be caused by the use of a poorly calibrated signal generator, will have poor sensitivity and selectivity, incorrect dial calibration, low power output, and poor a-v-c operation.

ORAL QUIZ

1. Name two receiver characteristics that are affected by the alignment.
2. Why are the i-f amplifiers aligned before any other circuit alignment is attempted?
3. In what order are the i-f amplifiers aligned?
4. What type of test equipment is necessary for aligning the crystal-filter circuit?
5. What circuit is aligned in the a-v-c section?
6. What type of signal is used during the alignment of the beat-frequency oscillator?
7. Name two factors which determine dial accuracy.
8. What two ways may the signal generator be connected to the receiver?
9. Why is it important, especially on the higher frequency bands, to check the tuning of the receiver after making each adjustment in the r-f section?
10. Why is it necessary to repeat the low-frequency and high-frequency adjustments of the r-f section on each band?

EXPERIMENT No. 11

TIME ALLOTTED: 2 HR.

SUBJECT

Alignment and adjustment.

OBJECTIVE

To become familiar with the proper alignment and adjustment procedure for the receiver.

EQUIPMENT REQUIRED

- 1 Radio Receiver BC-779-B.
- 1 Power-supply unit.

1 Interconnecting cable.

1 Accurately calibrated signal generator (100 kc. to 20 mc., with modulation).

1 Output meter (range 15 to 30 volts; internal resistance, 500 ohms or greater).

1 Insulated screw driver (9/64" wide and .025" thick at bit).

INSTRUCTIONS

Remove the dust cover and bottom plate from the receiver. Connect the receiver to the power-supply unit and plug the line cord into the a-c receptacle.

Turn the OFF-ON switch ON, and allow the receiver to warm up. Do not make any adjustments other than those outlined in the procedure.

PROCEDURE

Using the information in previous experiments for reference purposes, perform the alignment assigned by the instructor. When the alignment is completed,

report to the instructor, who will check the accuracy of the alignment.

CONCLUSIONS

A thorough knowledge of the alignment and adjustment procedure is necessary to obtain the best possible results in aligning the receiver.

LECTURE No. 14

TROUBLE-SHOOTING PROCEDURE

GENERAL

If the receiver operates incorrectly or does not operate at all, the trouble should be located quickly and efficiently, and the trouble-shooting procedure used should eliminate all doubt from the other associated circuits. A thorough visual inspection should be made first. Visually inspect all cables, terminal boards, wiring, and components for evidence of overheating or physical damage, and correct any troubles that are found.

Troubles that are not revealed by the visual inspection may be found by means of the following trouble-shooting procedure. This trouble-shooting procedure is logical, thorough, and easy to follow. It is based upon:

First—Localization of the trouble to a functional section, or block of circuits.

Second—Isolation of the faulty circuit within that section.

Third—Location of the defective part within that circuit.

Localization of the trouble to a functional section is accomplished, if possible, by an operational check, which is in chart form for convenience. By means of this check, the serviceman often can localize the trouble to a block of circuits immediately, without needless testing.

If the trouble cannot be localized by the operational check, it should be localized by a step-by-step trouble-shooting procedure (test-point check), test points,

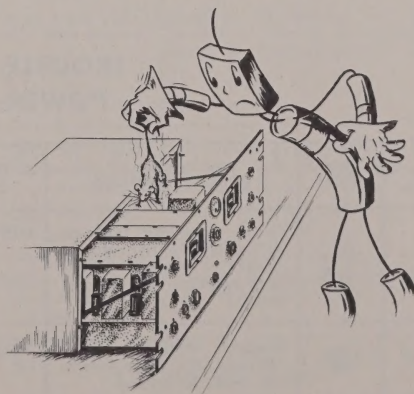
①, ②, etc.; a group of key test points, A, B, etc., and if required, a group of secondary test points, A1, A2, etc.; all test points are indicated on the schematic diagram and photographs.

Tests at the major test points throughout the equipment will definitely localize the trouble to a particular section, and eliminate other sections from suspicion. After the trouble has been localized to a section, either by the operational check or by tests at major test points, additional tests at the key and secondary test points, specified in the chart, will isolate the faulty circuit. The defective part can then be located by testing tubes, by further voltage and resistance measurements, or by substitution of parts.

OPERATIONAL CHECK

Make the following preliminary connections and settings of controls before making the checks given in the Operational-Check Chart:

1. Connect speaker to terminal board at rear of receiver.
2. Connect a-c power cord to the proper voltage source as determined by the power-supply unit used and the connections to the power-transformer primary.
3. Set CRYSTAL SELECTIVITY switch to OFF.
4. Set PHASING control to the arrow.
5. Set BAND WIDTH control to 3.
6. Turn LIMITER switch to OFF.
7. Set AVC-MANUAL switch to AVC.
8. Set SENSITIVITY control to 10.
9. Set BAND SPREAD dial to 100.
10. Set SIGNAL switch to MOD.
11. Set BEAT OSCILLATOR control to 0.
12. Set SEND-REC switch to REC.
13. Set AUDIO GAIN control to 6.



OPERATIONAL-CHECK CHART

STEP	BC-779-B CONTROL POSITIONS	NORMAL INDICATION	POSSIBLE CAUSE OF ABNORMAL INDICATION
1	OFF-ON power switch ON.	Dial and "S"-meter lights illuminate.	Fuse F1 or pilot lamps open. No a-c power. See Trouble-Shooting Chart, step 1.
2	Band switch turned to a band on which stations are known to be transmitting. MAIN TUNING control rotated slowly to tune in stations.	Loud, clear signals from many stations (MAIN TUNING dial indicates station frequency). "S" meter deflects in proportion to signal strength.	If only "S" meter gives normal indication, proceed to Trouble-Shooting Chart, step 7. If loud, clear signals are heard but there is no "S"-meter deflection, proceed to Trouble-Shooting Chart, step 23. If both indications are abnormal, proceed to Trouble-Shooting Chart, step 1.
3	Band switch turned to each of the remaining four bands in succession. Rotate MAIN TUNING control to tune in stations on each band.	Same as step 2, except that fewer stations may be received on less "active" bands.	If step 2 indication were normal and normal indications are not obtained for any band in step 3, proceed to Trouble-Shooting Chart, steps 17 through 22, to isolate trouble in faulty band.
4	AVC-MANUAL switch to MANUAL.	Tuning meter inoperative. Greater receiver sensitivity.	Trouble in a-v-c system. See Trouble-Shooting Chart, steps 23 and 24.
5	SIGNAL switch to CW.	Audio-output tone from c-w signals.	Trouble in b-f-o circuit. See Trouble-Shooting Chart, step 25.
6	LIMITER switch to ON.	Reduction of audio output. Improved signal-to-noise ratio on noisy signals.	Trouble in noise-limiter circuit. See Trouble-Shooting Chart, step 26.
7	CRYSTAL SELECTIVITY switch to 1, 2, 3, 4, and 5, in sequence.	Increased selectivity with each succeeding position of switch.	Fault in crystal-filter assembly. Check individual components.

TEST-POINT CHECK

The following test equipment is required for making the test-point check:

- 1 R-f signal generator (100 kc.—20 mc.).
- 1 A-f signal generator.
- 1 D-c vacuum-tube voltmeter, or 20,000-ohms-per-volt, d-c voltmeter.

Before making the tests given in the Trouble-Shooting Chart, set the receiver controls as follows:

- 1. Set CRYSTAL SELECTIVITY switch to OFF.
- 2. Set PHASING control to the arrow.
- 3. Set BAND WIDTH control to 3.
- 4. Turn LIMITER switch to OFF.
- 5. Set AVC-MANUAL switch to AVC.
- 6. Set SENSITIVITY control to 10.
- 7. Set BAND SPREAD dial to 100.
- 8. Set SIGNAL switch to MOD.
- 9. Set BEAT OSCILLATOR control to 0.
- 10. Set SEND-REC switch to REC.
- 11. Set AUDIO GAIN control to 6.

TROUBLE-SHOOTING CHART POWER-SUPPLY CIRCUITS

STEP	TEST POINT	TEST EQUIPMENT CONTROL POSITIONS	BC-779-B CONTROL POSITIONS	NORMAL INDICATION	POSSIBLE CAUSE OF ABNORMAL INDICATION
1		Connect positive lead of voltmeter (0—500-volt, d-c range) to terminal 4; connect negative lead to terminal 7.	OFF-ON switch ON.	+170 volts approx.	Trouble in power-supply or voltage-distribution circuits of receiver. Check fuse F1, transformers T1, T2, and T3, and switch SW6; then proceed to step 2.
2		Connect voltmeter (0—500-volt, d-c range) from test point to ground.	Same as step 1.	—60 volts approx.	Tube V2, Capacitor C2. Resistor R2A, R2B, or R2C. Resistor R38, R39, or R40.

TROUBLE-SHOOTING CHART (Continued)

POWER SUPPLY

STEP	TEST POINT	TEST EQUIPMENT CONTROL POSITIONS	BC-779-B CONTROL POSITIONS	NORMAL INDICATION	POSSIBLE CAUSE OF ABNORMAL INDICATION
3	B	Same as step 2.	Same as step 1.	+110 volts approx.	Capacitor C53, C43, C20A, C27, C19A, C31B, C18C, C9, C5, C18A, C10A, or C6, in receiver trouble in power supply; proceed to step 4.
4	B1	CAUTION: High Voltage! Disconnect a-c power cord from power source, and remove cable from terminal board at rear of power supply. Connect jumper wire between terminals 8 and 9 of terminal board. Connect voltmeter (0—750-volt, d-c range) from test point to ground. Reconnect a-c power cord to power source.		+520 volts to +550 volts.	Capacitor C1. Choke L1.
5	B	Same as step 4.	Same as step 4.	+240 volts approx.	Choke L2. Capacitor C1. Resistor R1A or R1B.

RECEIVER CIRCUITS

6	2	Connect modulated r-f signal-generator output to test point. Adjust attenuator for weak r-f output, and adjust generator to the following frequencies, in sequence: 150 kc. 300 kc. 3.5 mc. 7.5 mc. 15.0 mc.	Band Switch MAIN TUNING 100-200 kc. 150 kc. 200-400 kc. 300 kc. 2.5- 5.0 mc. 3.5 mc. 5- 10 mc. 7.5 mc. 10- 20 mc. 15.0 mc. Adjust MAIN TUNING control slightly to tune in signal.	Loud, clear signal from loud-speaker.	If loud, clear signal is not heard on each band, proceed to step 7. If abnormal indication on one or more (but not all) bands is obtained, proceed to step 17.
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AUDIO-FREQUENCY CIRCUITS

7	C	Connect ground lead of audio signal generator to receiver chassis; connect output lead to test point through .1-mf. capacitor. Use weak output.	AUDIO GAIN to 10.	Very loud, clear tone from speaker.	Speaker. Trouble in a-f circuits; proceed to step 8. If normal indication is obtained, proceed to step 12.
8	C1	Same as step 7, except use strong output.	Same as step 7.	Clear tone from speaker.	Tube V15. Transformer T7 or T8. Capacitor C28. Resistor R36.
9	C2	Same as step 8.	Same as step 7.	Clear tone from speaker.	Tube V16. Transformer T7 or T8.
10	C3	Same as step 8.	Same as step 7.	Louder tone from speaker than in step 9.	Tube V14. Capacitor C25. Resistor R29, R38, R39, or R40.
11	C	Same as step 7.	Same as step 7.	Same as step 7.	Resistor R26. Tube V13. Resistor R38, R27, or R28.

TROUBLE-SHOOTING CHART (Continued)

I-F AND 2nd-DETECTOR CIRCUITS

STEP	TEST POINT	TEST EQUIPMENT CONTROL POSITIONS	BC-779-B CONTROL POSITIONS	NORMAL INDICATION	POSSIBLE CAUSE OF ABNORMAL INDICATION
12	D	Connect r-f signal-generator ground lead to receiver chassis; connect output lead to test point. Turn on modulation. Adjust frequency for 465-kc. output.	Set AVC-MANUAL switch to MANUAL.	Loud, clear signal from speaker when using weak signal generator output.	Trouble in i-f and 2nd-detector circuits; proceed to step 13. If normal indication is obtained, proceed to step 17.
13	D1	Same as step 12.	Same as step 12.	Clear signal from speaker.	Tube V7 or V8. Resistor R47, R24, R26, or R48. Capacitor C20C or C24.
14	D2	Same as step 12.	Same as step 12.	Louder signal from speaker than in step 13.	Tube V6. Resistor R21. Capacitor C19C. Misaligned or defective transformer T3.
15	D3	Same as step 12.	Same as step 12.	Louder signal from speaker than in step 14.	Tube V5. Resistor R17. Capacitor C18C. Misaligned or defective transformer T2.
16	D	Same as step 12.	Same as step 12.	Same as step 12.	Tube V3. Capacitor C14. Resistor R15. Misaligned or defective transformer T1.

H-F OSCILLATOR CIRCUITS

17	E	Connect positive lead of v.t.v.m. (0—10-volt, d-c range) to chassis; connect negative lead to test point.	Tune through entire tuning range on all bands.	At least —3 volts.	Tube V4. Capacitor C16. Resistor R14 or R13. Switch SW1E. Tuned circuit for each band.
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R-F AMPLIFIER AND MIXER CIRCUITS

18	F	Connect r-f signal-generator output to test point. Adjust signal-generator attenuator for weak output, turn modulation on, and adjust generator to the following frequencies, in sequence: 150 kc. 300 kc. 3.5 mc. 7.5 mc. 15.0 mc.	AVC-MANUAL switch to MANUAL. Band MAIN Switch TUNING 100-200 kc. 150 kc. 200-400 kc. 300 kc. 2.5- 5.0 mc. 3.5 mc. 5- 10 mc. 7.5 mc. 10- 20 mc. 15.0 mc. Adjust MAIN TUNING control slightly to tune in signal.	Loud, clear signal from speaker.	Trouble in r-f circuits; proceed to step 19. If normal indication is obtained, proceed to step 23.
19	F1	Connect r-f signal-generator between test point and ground. Increase r-f output and adjust generator to frequencies given in step 18.	Same as step 18.	Clear signal from speaker.	Tube V3. Capacitor C13. Resistor R11. Misaligned or defective oscillator tank for the defective band.
20	F2	Same as step 19.	Same as step 18.	Louder signal from speaker than in step 19.	Tube V2. Capacitor C9. Resistor R8. Switch SW1D. Misaligned or defective mixer circuit for the defective band.
21	F3	Same as step 19.	Same as step 18.	Louder signal from speaker than in step 20.	Tube V1. Capacitor C5. Resistor R4. Misaligned 2nd r-f circuit for the defective band.
22	F	Same as step 18.	Same as step 18.	Same as step 18.	Antenna terminal E1. Switch SW1B. Misaligned 1st r-f circuit.

TROUBLE-SHOOTING CHART (Continued)

A-V-C CIRCUITS

STEP	TEST POINT	TEST EQUIPMENT CONTROL POSITIONS	BC-779-B CONTROL POSITIONS	NORMAL INDICATION	POSSIBLE CAUSE OF ABNORMAL INDICATION
23		None.	AVC-MANUAL switch to AVC. Tune in a strong phone station.	"S" meter deflects to right when receiver is tuned to a signal.	Tube V11 or V12. Capacitor C29. Resistor R37 or R51. Misaligned or defective transformer T6.
24		Connect v.t.v.m. (0—10-volt range), or 20,000-ohms-per-volt d-c voltmeter between test point and ground.	Set SENSITIVITY control to 10.	—8 volts approx.	Capacitor C56, C17, or C18B. Resistor R52.

BEAT-FREQUENCY-OSCILLATOR CIRCUIT

25		None.	Set SIGNAL switch to CW. Tune in strong c-w signal.	Whistle from speaker.	Tube V10. Capacitor C41 or C49. Resistor R34, R35, or R33. Misaligned transformer T5. Switch SW3.
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NOISE-LIMITER CIRCUIT

26		None.	Tune in phone signal on noisy band. Turn SIGNAL switch to MOD. Turn LIMITER switch to ON.	Reduction of audio volume, but with improved signal-to-noise ratio.	Tube V9. Capacitor C42. Resistor R49. Switch SW9.
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LESSON PLAN No. 14

TIME ALLOTTED: 3 HR.

SUBJECT

Philco Trouble-Shooting Procedure.

OBJECTIVE

To become familiar with a logical trouble-shooting procedure for determining causes of equipment failure.

INTRODUCTION

A logical method of trouble-shooting is the key to efficient equipment repair.

SUBJECT MATERIAL

1. Discuss the over-all advantages of a logical trouble-shooting procedure.
2. Discuss the method of checking the equipment visually.
3. Explain the Philco Trouble-Shooting Procedure, mentioning the following:
 - a. Three basic steps of procedure.
 - b. Use of major test points.
 - c. Use of key test points.
 - d. Use of secondary test points.
 - e. Method of locating the defective part after the trouble has been isolated to a particular section.
4. Using the Operational-Check Chart, explain each of the steps in order.

5. Outline the test equipment required for making the trouble-shooting tests.

6. Give the preliminary settings of the front-panel controls.

7. Using the Trouble-Shooting Chart, explain the method of testing each of the following circuits:

- a. Power-supply circuits.
- b. Receiver circuits.
- c. Audio-frequency circuits.
- d. I-F and 2nd-detector circuits.
- e. H-F oscillator circuits.
- f. R-F amplifier and mixer circuits.
- g. A-V-C circuit.
- h. Beat-frequency-oscillator circuit.
- i. Noise-limiter circuits.

(8) Using Wall Chart No. 1 and Wall Chart No. 2, place a number of hypothetical troubles in the equipment and illustrate the manner in which these troubles may be isolated by use of the Philco Trouble-Shooting Method.

CONCLUSIONS

The use of a logical trouble-shooting procedure, such as the Philco Trouble-Shooting Procedure, will eliminate guess work, and will enable the repairman to find any trouble in the receiver quickly and efficiently.

ORAL QUIZ

1. What are the two primary objectives of using a logical method of trouble shooting?

2. When a receiver operates incorrectly what is the first thing that must be done before any trouble shooting is attempted?

3. What are the three basic steps of the Philco Trouble-Shooting procedure?

4. What is the purpose of the major test points?

5. What is the purpose of key test points?

6. What is the purpose of secondary test points?

7. After trouble has been localized to a section, what method is used to locate the defective part?

8. What is the basic function of the Operational Check?

9. What circuits are checked by major test point

①?

10. What circuits are checked by major test point

②?

EXPERIMENT No. 12

SUBJECT

Trouble shooting.

OBJECTIVE

To become familiar with the method of trouble shooting the receiver.

EQUIPMENT REQUIRED

1 R-F signal generator (100 kc.—20 mc.).

1 A-F signal generator.

1 D-C vacuum-tube voltmeter, or 20,000-ohms-per-volt, d-c voltmeter.

INSTRUCTIONS

Do not handle the equipment until the instructor gives the signal to start work.

TIME ALLOTTED: 4 HR.

PROCEDURE

1. The receiver has a particular trouble, or troubles, placed in it by the instructor. Using the trouble-shooting method outlined in the lecture and the information from previous experiments, locate and correct all troubles and report the findings to the instructor.

CONCLUSIONS

Trouble-shooting ability is judged in terms of the trouble-shooting procedure used, the speed in locating trouble, and the quality of the repair. In this experiment, your ability will be evaluated by the instructor.

LECTURE No. 15

PREVENTIVE MAINTENANCE

By performing the prescribed operations in the following preventive-maintenance procedure, at the intervals specified, many troubles may be prevented from occurring, and the receiver will be maintained at the best possible operating efficiency. Any discrepancies noticed while performing the routine maintenance steps should be corrected as soon as possible.

1. Preventive-Maintenance Checks.

a. Daily inspection—Check the receiver operation daily, using the operational check given in Lecture No. 14.

b. Weekly Inspections—Measure the voltages at terminal strip E4 in the receiver, or E1 on the power-supply unit. These measurements will indicate troubles not otherwise seen in the operational check. A reliable voltmeter should be used, and the voltage readings should be checked against those given in the power-supply checks in Lecture No. 14.

c. Monthly Inspections.

(1) Remove the dust covers from both the receiver

and power-supply unit, and remove all dust. Clean potted chokes and transformers in the power supply, to remove any oil which may have collected. Excessive dust on these components may cause overheating and damage to the parts.

(2) Using a reliable tube tester, check all tubes for shorts, gaseous conditions, noise, and transconductance.

2. Lubrication.

The time intervals for lubricating the receivers are dependent upon the type of operation. If the receiver is to be stored, it should be lubricated before storing. If the receiver has been stored and is to be put into operation, it should be inspected, and lubricated where necessary. The receiver should be lubricated every three months if it is operated normally eight hours a day. The interval of lubrication should be lengthened or shortened according to the normal daily operation.

The materials required for lubrication are listed in the following chart:

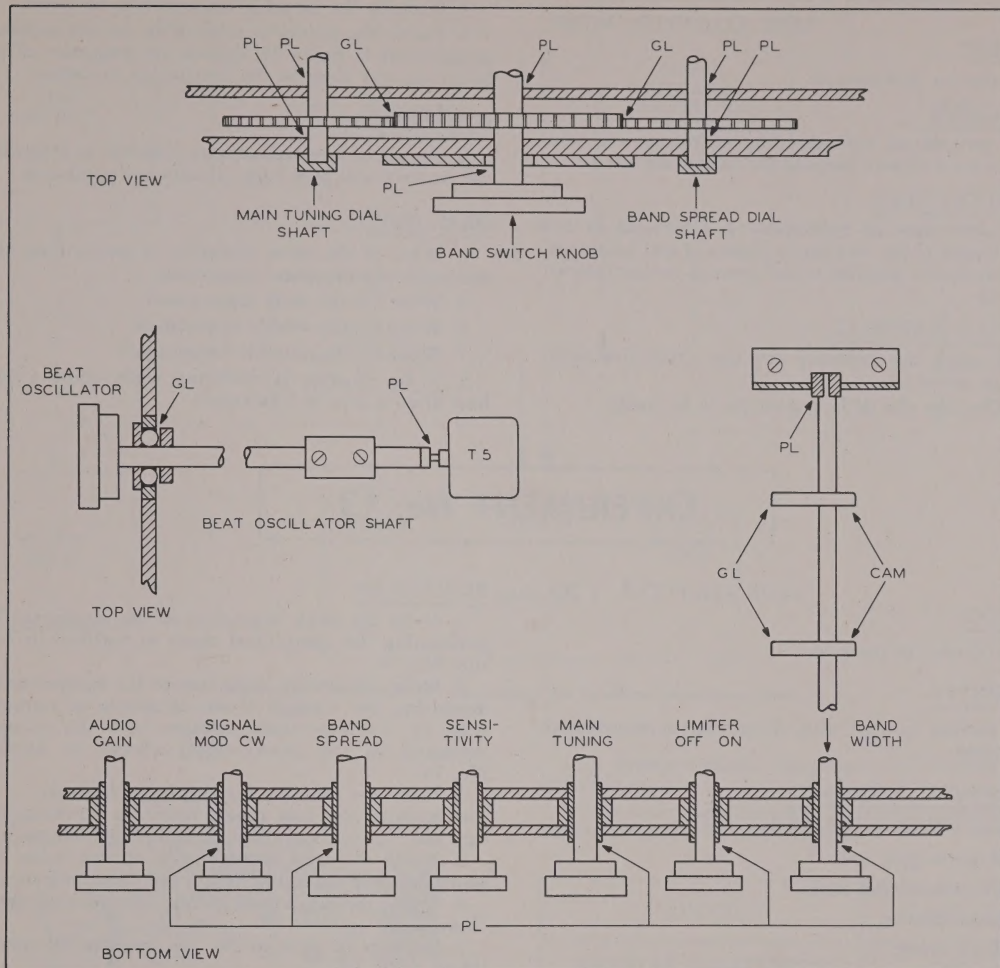
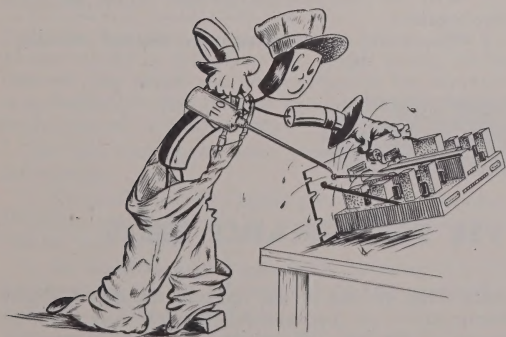


Figure 25. Locations of Lubrication Points in Receiver

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SYMBOL	STANDARD NOMENCLATURE
PL-SPECIAL	Oil, lubricating, preservative, special
GL	Grease, lubricating, special
SD	Solvent, dry cleaning

The lubrication points are illustrated in figure 25. Before lubricating these points, clean them thoroughly with solvent, and dry them with a lint-free cloth. Where oil is required, apply only one drop of PL-SPECIAL; where grease is required, apply a thin coat of GL. After the lubricant has been applied, rotate the control to distribute the lubricant evenly, and remove excess lubricant.

LESSON PLAN No. 15

TIME ALLOTTED: $\frac{3}{4}$ HR.

SUBJECT

Preventive maintenance.

OBJECTIVE

To provide an understanding of the various preventive-maintenance inspections which are used.

INTRODUCTION

Troubles may be prevented or discovered in the early stages, if the receiver is inspected and lubricated at the intervals specified in the preventive-maintenance schedule.

SUBJECT MATERIAL

1. Explain the necessity for the preventive-maintenance schedule.
2. Describe the daily inspection to be made.

3. Describe the weekly inspection to be made.
4. Describe the monthly inspection to be made.
5. Locate the points of lubrication on the receiver, as indicated in figure 25; discuss the frequency of lubrication, and describe the lubrication procedure.

CONCLUSIONS

If the preventive-maintenance schedule is followed, the receiver will give long, trouble-free operation.

ORAL QUIZ

1. What is the main objective in performing the preventive-maintenance inspections?
2. What are the daily inspections?
3. What are the weekly inspections?
4. What are the monthly inspections?
5. If the receiver is operating eight hours a day, how often is it to be lubricated?

EXPERIMENT No. 13

TIME ALLOTTED: 1 HR.

SUBJECT

Preventive maintenance.

OBJECTIVE

To become familiar with the preventive maintenance procedure.

EQUIPMENT REQUIRED

- 1 Radio Receiver BC-779-B.
- 1 Power-supply unit.
- 1 Interconnecting cable.
- 1 Loud-speaker.
- 1 Tube tester.
- 1 D-C voltmeter (20,000-ohm-per-volt sensitivity).

INSTRUCTIONS

Connect the receiver to the power-supply unit. Plug the line cord into the a-c receptacle. Do not make any adjustment other than those outlined in the procedure.

PROCEDURE

1. Make the daily inspection of the equipment by performing the operational check as outlined in Lecture No. 14.
2. Make the weekly inspection of the equipment by measuring the voltages at the terminals on terminal strip E4. Compare these voltages with the voltages measured in the power-supply checks in Lecture No. 14.
3. Make the monthly inspections as follows:
 - a. Remove the dust covers from the power-supply unit and receiver, and clean the equipment thoroughly.
 - b. Using the tube tester, check all the tubes for shorts, gaseous conditions, noise, and transconductance.
4. Locate the lubrication points, and lubricate them, if required.
5. Replace the dust covers, and perform the operational check.

CONCLUSIONS

1. What is purpose of making the operational checks daily?
2. Why are the voltages checked at the terminal strip weekly?
3. Why must the equipment be cleaned monthly?

LECTURE No. 16

SPECIAL INFORMATION — RECEIVER PERFORMANCE TESTS

When the receiver is operating properly it should meet certain standards of performance. Although the alignment may be correct, the over-all performance of the receiver may still be inferior, due to the improper

functioning of one of the receiver circuits. A slight deterioration in performance, which may not be noticed during normal operation, can be discovered by making the following tests.

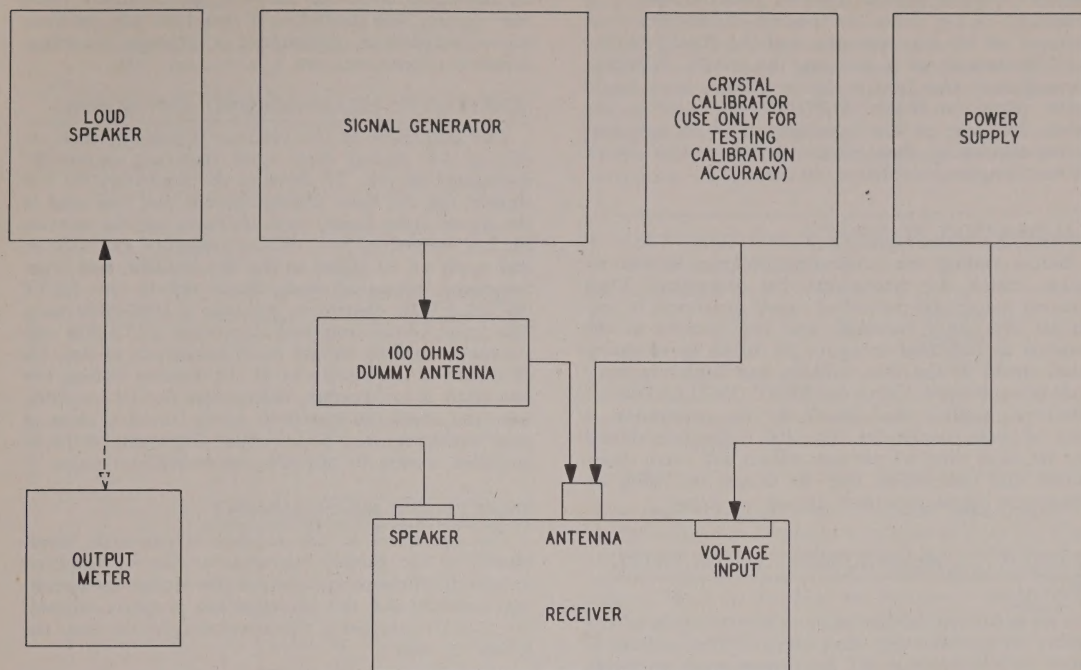


Figure 26. Test-Equipment Connections for Receiver Performance Tests

TP-9898

4. A dummy antenna, consisting of a 100-ohm non-inductive resistor.

Set the front panel controls as follows unless directed otherwise under the individual tests.

CONTROL	POSITION
CRYSTAL SELECTIVITY	OFF
PHASING	Arrow
BAND WIDTH	3
LIMITER	OFF
AVC-MANUAL	AVC
SENSITIVITY	10
BAND SPREAD	100
SIGNAL	MOD
AUDIO GAIN	6
SEND-REC	REC
BEAT OSCILLATOR	0
OFF-ON	ON
MAIN TUNING	Nominal

PRELIMINARY INSTRUCTIONS

Before any tests are made, make certain that the power supply is delivering the proper power to the receiver, and check the test equipment for accuracy. It is important that the test equipment be connected to the receiver in the prescribed manner.

The test instruments must meet the following requirements:

1. A crystal-controlled signal generator, or secondary frequency standard, with an accuracy of .01 percent at 100 kc. and 1000 kc.
2. An accurate signal generator, covering the frequency range of the receiver, and having modulation facilities of 30% at 400 c.p.s.
3. An output meter, with a terminal impedance of 600 ohms, and a range of 0 to 100 volts.

BEAT-FREQUENCY OSCILLATOR

Since the beat-frequency oscillator is used in most of these tests, its performance should be checked first. Connect the signal generator, dummy antenna, and loud-speaker to the receiver as indicated in figure 26.

Adjust the signal generator for an unmodulated signal frequency on any one of the frequency bands. With the receiver set for c-w operation and the BEAT OSCILLATOR control set to 0, rotate the MAIN TUNING control until zero beat is obtained. Zero beat should occur when the MAIN TUNING dial is set to the exact frequency of the signal-generator. If zero beat is not obtainable, then trouble is indicated in the i-f or beat-frequency-oscillator circuits.

CALIBRATION ACCURACY

Before testing the calibration accuracy of the receiver, check the mechanical dial alignment. Then connect the crystal-controlled signal generator, or secondary frequency standard, and loud-speaker to the receiver as indicated in figure 26. Inject an unmodulated signal at the low, middle, and high-frequency ends of each band. Using the BEAT OSCILLATOR to obtain an audible tone, check the dial calibration at each of these frequencies. The dial calibration should not be more than 1.5 per cent off on any band. Inaccurate dial calibration may be caused by using an inaccurate signal generator during alignment.

SENSITIVITY MEASUREMENT (MODULATED SIGNAL)

The sensitivity of the receiver is a measure of the ability to receive very weak signals. The receiver is rated for a sensitivity of 2 microvolts input to obtain 17.3 volts output on all bands. The sensitivity is dependent upon proper alignment and operation of all circuits.

To measure the sensitivity, connect the r-f signal generator, dummy antenna, and output meter to the receiver as shown in figure 26. Apply a signal with 30% modulation to the receiver at the low, middle, and high-frequency ends of each band. Adjust the signal-generator output at each frequency for a 17.3-volt reading on the output meter. The maximum input voltage required should be 2 microvolts on all bands.

SIGNAL (PLUS NOISE)-TO-NOISE RATIO

The maximum amount of noise tolerable in the receiver is checked for by the signal (plus noise)-to-noise ratio test. This test is usually made with the sensitivity measurement (modulated signal). After each sensitivity measurement, turn off the modulation of the signal generator and record the output-meter reading. The output-meter readings under these conditions should be as follows:

INPUT	FREQUENCY	OUTPUT ACROSS 600 OHMS
2 MV	10—20 mc.	8.6 volts (2:1 ratio)
2 MV	All other bands	5.7 volts (3:1 ratio)

If the signal (plus noise)-to-noise ratio is much lower than recommended, noisy operation is indicated in the

r-f amplifiers, mixer or 1st i-f stage. Changing tubes may correct this condition; if not, look for overheating of components, ungrounded or improper shielding, defective connections, etc.

SENSITIVITY MEASUREMENT (CW SIGNAL)

The sensitivity of the receiver is greater when receiving c-w signals than when receiving amplitude-modulated signals. To measure the sensitivity for c-w signals, use the same test equipment that was used in the signal (plus noise)-to-noise ratio. Set the receiver for c-w operation, turn off the generator modulation, and apply an r-f signal at the low, middle, and high-frequency points of each band. Adjust the BEAT OSCILLATOR control to produce a 1000-cycle tone. The input voltage required to produce a 17.3-volt output-meter reading should be .6 microvolt, or less, for all bands. If the sensitivity of the receiver during c-w operation is not correct, change the 3rd i-f amplifier tube and check the sensitivity again. Another cause of poor sensitivity may be improper alignment of the i-f amplifier section or beat-frequency-oscillator stage.

SELECTIVITY MEASUREMENT

The selectivity of the receiver is primarily determined by the proper operation of the i-f amplifier section. If all the components in this section are operating correctly and the i-f stages are properly aligned, the receiver selectivity characteristics should meet the following tests.

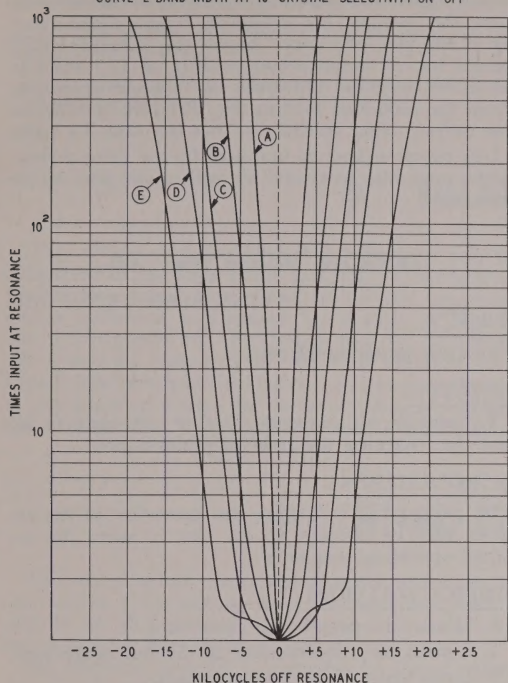
Crystal Out of Circuit

Connect the r-f signal generator, dummy antenna, and output meter in the same manner as for the sensitivity measurements. Set the AVC-MANUAL control to MAN, and the AUDIO GAIN to 10. Apply a 100-microvolt signal at 380 kc., with 30% modulation at 400 c.p.s. Adjust the sensitivity control for an output-meter reading of 17.3 volts. Increase the signal strength to 10 times (1000 microvolts) the previous value. The output meter should show a decided increase in output voltage. Tune the signal generator to one side of the test frequency, and note that the output voltage drops. The frequency at which the output-meter reading is exactly 17.3 volts is the band-width limit on this side of the test frequency. Repeat the same procedure to find the band-width limit on the other side of the test frequency. The difference between the two frequencies on either side of the test frequency is the band width. Check the band width at 100 times (10,000 microvolts) and 1000 times (100,000 microvolts) the test signal strength. The minimum band-width requirements at the various signal strengths are:

INPUT SIGNAL STRENGTH	BAND WIDTH
10 × (1000 microvolts)	3.5 to 7kc.
100 × (10,000 microvolts)	Below 12kc.
1000 × (100,000 microvolts)	Below 18kc.

The selectivity curve of the receiver with the crystal-filter circuit turned OFF, for various positions of the BAND WIDTH control, is shown in figure 27.

CURVE A BAND WIDTH AT 3 CRYSTAL SELECTIVITY "ON" "OFF"
 CURVE B BAND WIDTH AT 3 CRYSTAL SELECTIVITY "ON" "OFF"
 CURVE C BAND WIDTH AT 6 CRYSTAL SELECTIVITY "ON" "OFF"
 CURVE D BAND WIDTH AT 10 CRYSTAL SELECTIVITY "ON" "OFF"
 CURVE E BAND WIDTH AT 16 CRYSTAL SELECTIVITY "ON" "OFF"



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Figure 27. Selectivity Characteristics of Receiver

Crystal in Circuit

To measure the selectivity of the receiver with the crystal filter in the circuit, set the receiver front panel controls and connect the test equipment in the same manner as for the measurement of the selectivity with the crystal out of the circuit. Set the CRYSTAL SELECTIVITY control to position 4. Apply a 10,000-microvolt r-f signal at 380 kc., with 30% modulation at 400 c.p.s., and determine the band width, using the same procedure as for the measurement with the crystal out of the circuit. The total band width, for this position of the CRYSTAL SELECTIVITY switch, should be less than 5 kc. Figure 27 shows the selectivity curve of the receiver for position 1 of the CRYSTAL SELECTIVITY control.

IMAGE-REJECTION RATIO

When an "image" signal, which is 930 kc. above the desired signal, heterodynes with the h-f oscillator signal, an undesired i-f signal will be produced. This signal will be amplified along with the desired i-f signal in the i-f amplifier section, and cause interference. The image-rejection ratio is a measure of the receiver's ability to prevent "image" signals from reaching the i-f stages. An incorrect image-rejection ratio indicates poor r-f alignment or, if a component

has been replaced, improperly spaced leads, lengthy interstage coupling leads, etc.

To check the image-rejection ratio of the receiver, connect the signal generator, output meter, and dummy antenna to the receiver as shown in figure 26. Adjust the AVC-MANUAL switch to the MAN position, and the AUDIO GAIN to 10. The six test frequencies, with the corresponding image-rejection ratios are as follows:

TEST FREQUENCY IN KILOCYCLES	IMAGE-REJECTION RATIO
200	100,000 to 1
400	100,000 to 1
2,500	9,000 to 1
5,000	3,000 to 1
10,000	800 to 1
20,000	200 to 1

The image-rejection ratio at each of these frequencies is determined in the following manner: Set the signal generator to one of the test frequencies, with the modulation set for 400 c.p.s.; adjust the output for 5 microvolts. Tune the receiver for maximum output at the test-signal frequency. Adjust the SENSITIVITY control for 17.3-volt reading on the output meter. Readjust the signal generator for a signal 930-kc. above the test frequency. Using the image-rejection ratio given for the test signal, multiply the 5-microvolt signal by it for the proper output of the signal generator. For example, if the test frequency is 2500 kc., the corresponding rejection ratio is 9000 to 1; therefore, the signal generator output should be adjusted to 5 microvolts times 9000, or 45,000 microvolts. Do not disturb the setting of the receiver SENSITIVITY control. Increasing the signal-generator output to the value determined from the image-rejection ratio should not cause the receiver output to exceed 17.3 volts.

I-F REJECTION RATIO

To prevent interference, any r-f signal, at the receiver input, of the same frequency as the intermediate frequency must be prevented from reaching the i-f amplifier section directly. Misalignment of the r-f section, or improperly placed r-f and i-f leads, may allow such signals to get through. The i-f-rejection ratio is an indication of the receiver's ability to reject signals at the intermediate frequency, and should be measured to make certain that the receiver has the proper rejection characteristics. The test-signal frequencies and the corresponding i-f-rejection ratios are as follows:

SIGNAL FREQUENCY IN KILOCYCLES	I-F-REJECTION RATIO
200 and down	100,000 to 1
400	100 to 1
2500 and up	100,000 to 1

Set the AVC-MANUAL switch to MAN, and the AUDIO GAIN to maximum. Set the signal generator for one of the signal frequencies, with the modulation set for 400 c.p.s. Adjust the signal-generator output for 5 microvolts. Tune the receiver for maximum output at the signal frequency. Adjust the receiver SENSITIVITY control for a 17.3-volt reading on the output meter. Readjust the signal generator for a 465-kc. signal. Using the proper i-f rejection ratio, given in the table, multiply the 5-microvolt signal by it, and adjust the signal-generator output to the value obtained. Increasing the signal-generator output to this value should not cause the receiver output to exceed 17.3 volts.

A-V-C CHARACTERISTICS

The automatic-volume-control circuits are designed to adjust the sensitivity of the controlled stages, for varying input signals, to maintain a relatively constant output. Failure of the receiver to maintain a constant output may be caused by poor alignment of the i-f section or a-v-c amplifier stage, or defective operation of the a-v-c circuits.

To check the action of the a-v-c circuit, proceed as follows:

Set the front-panel controls as directed in the preliminary instructions. Connect the signal generator, dummy antenna, and output meter to the receiver as indicated in figure 26. A 2.5-mc. signal, modulated at 400 c.p.s., is used in this test. Adjust the signal-generator output for 5 microvolts, and tune the receiver for maximum output at the test frequency. Adjust the AUDIO GAIN control for a 10-volt output-meter reading. Increase the output of the signal generator from 5 to 50,000 microvolts. The output-meter reading should not go over 50 volts.

POWER OUTPUT AT SPEAKER

Modulated Signal

For this test, all of the receiver controls except the AVC-MANUAL switch and the AUDIO GAIN control are set to the positions given in the preliminary instructions. Set the AVC-MANUAL switch to MAN, and the AUDIO GAIN control to maximum. Connect the signal generator, dummy antenna, and output meter to the receiver as shown in figure 24. Apply a 1000-microvolt signal at 2.5 mc. modulated 30% at 400 c.p.s. With the AUDIO GAIN and SENSITIVITY controls at maximum, the output-meter reading should not be less than 77 volts.

C-W Signal

The positions of the receiver front-panel controls are the same as for preceding test except that the SIGNAL switch is placed in the CW position. Using the same test-equipment set-up, apply a 1000 microvolt, unmodulated 2.5-mc. signal to the receiver. Tune the receiver to the test frequency for maximum output-meter reading. Adjust the BEAT OSCILLATOR control to produce a 1000-cycle tone. With the AUDIO GAIN and SENSITIVITY controls at maximum, the output meter should read not less than 54 volts.

POWER OUTPUT AT PHONE JACK

The positions of the receiver front-panel controls and the connections of the test equipment are the

same as in the Power Output at Speaker test for a modulated test. Connect an 8000-ohm resistive load across the phone terminal. Apply a 1000-microvolt, 2.5-mc. signal, modulated at 400 c.p.s., to the receiver. Tune the receiver for maximum output-meter reading at the test frequency. Adjust the SENSITIVITY control for an output-meter reading of 17.3 volts at the SPKR terminal. Measure the voltage developed across the 8000-ohm load at the "PHONE" terminals. The output meter should read not less than 8.3 volts.

Low power output as indicated by the three power-output tests, may be caused by weak tubes, poor alignment, etc.

LESSON PLAN No. 16

TIME ALLOTTED: 2 HR.

SUBJECT

Receiver performance tests.

OBJECTIVE

To provide an understanding of the tests to be made for checking the receiver performance.

INTRODUCTION

By performing these tests the operation of the receiver may be checked to see that it meets the required operating standards.

SUBJECT MATERIAL

1. Discuss the purpose for these tests.
2. Discuss the requirements of the test equipment.
3. Draw figure 26 on the blackboard.
4. Describe the position of the receiver front-panel controls prior to making these tests.
5. Describe the following tests, explaining the position of the receiver front-panel controls and the method of connecting the test equipment.
 - a. Beat-frequency oscillator.
 - b. Calibration accuracy.
 - c. Sensitivity measurement (modulated signal).
 - d. Signal (plus noise)-to-noise ratio.
 - e. Sensitivity (c-w signal).
 - f. Selectivity measurement.
 - g. Image-rejection ratio.
 - h. I-F-rejection ratio.
 - i. A-V-C characteristic.
 - j. Power output at speaker.
 - (1) Modulated signal.
 - (2) C-W signal.
 - k. Power output at phone jack.

CONCLUSIONS

Where the required test instruments are available and the receiver has been repaired, or stored for any length of time, the receiver should be checked to see that it meets the tests given in this lecture.

ORAL QUIZ

1. Why must very accurate test instruments be used when making the receiver performance tests?
2. What is the maximum tolerable percentage of error allowable on the MAIN TUNING dial?

3. What is the sensitivity of the receiver for a modulated signal on all bands?

4. Noisy operation of what stages could cause an incorrect signal (plus noise)-to-noise ratio?

5. What is the sensitivity of the receiver for c-w signals on all bands?

6. At what frequency above the desired signal is the "image" located?

7. Misalignment of what circuits would cause incorrect i-f-rejection ratio?

8. Name two conditions which may cause low power output?

9. What two conditions may cause poor a-v-c operation?

10. What circuits primarily determine the selectivity characteristics of the receiver?

◆ FINAL REVIEW ◆

This review requires about four hours, and is to be conducted in the form of an oral quiz. Display Wall Charts No. 1 and No. 2, and review the important points contained in Lectures No. 8 through No. 16 and Experiments No. 5 through No. 12, by asking the questions contained in the Oral Quiz of each Lesson Plan and the Conclusions of each experiment. If any question causes the students difficulty, explain the answer fully. The students should be permitted at

regular intervals during the review, to ask questions of their own that pertain to the subject material. Make note of each question on which the students indicate a general weakness.

Referring to the notes made during this review and previous reviews, thoroughly discuss the questions which have caused the students general difficulty throughout the course.

◆ FINAL EXAMINATION ◆

The examination covers the material contained in this course. The normal time allotment for Parts I and II of this examination is approximately two hours, and for Part III approximately one hour.

No reference material is necessary for Part I. After Part I is finished the instructor will collect the papers. Wall Charts No. 1 and No. 2 are necessary for Part II. Do not start Part II until given the signal by the instructor. Part III is a trouble-shooting examination to be conducted in the laboratory.

PART I MULTIPLE CHOICE

1. When the MAIN TUNING dial is set to 3000 kc. and the BAND SPREAD dial is set to 50:

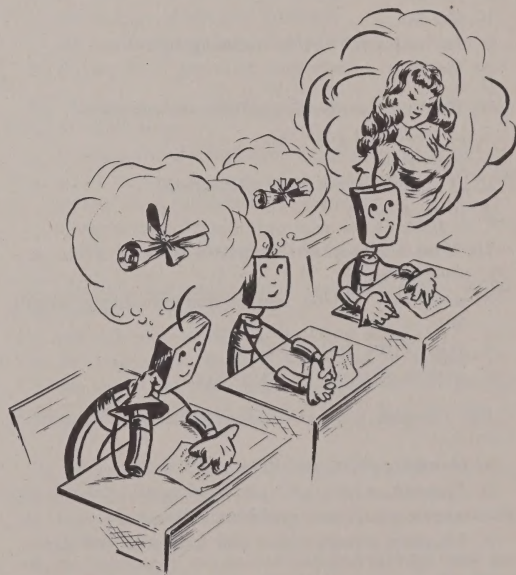
- the receiver is tuned to a frequency higher than 3000 kc.
- the receiver is tuned to a frequency lower than 3000 kc.
- the i-f amplifiers are tuned to a frequency lower than 465 kc.
- the i-f amplifiers are tuned to a frequency higher than 465 kc.

2. Crystal Y1 has a:

- very high Q and low L/C ratio.
- very low Q and high L/C ratio
- very high Q and high L/C ratio.
- very low Q and low L/C ratio.

3. The main advantage of the BAND WIDTH control is that it allows the operator to adjust the:

- selectivity for the best quality with a minimum of interference.
- sensitivity for best signal-to-noise ratio.
- tuning of the i-f amplifiers for different signals.
- a-v-c level for various signal strengths.



4. The noise limiter is designed to limit noise interference consisting of:

- pulses of very short duration, during c-w operation only.
- pulses of very short duration.
- pulses of very long duration.
- pulses of very long duration, during c-w operation only.

5. The 2nd detector is designed to:
 - a. rectify the audio signal and amplify it.
 - b. rectify the i-f signal and extract the audio component.
 - c. rectify the i-f signal and extract the r-f component.
 - d. amplify the i-f signal and extract the audio component.
6. If the a-v-c circuits are aligned correctly and an output meter is connected to the speaker terminals:
 - a. the output-meter reading should peak as the "S"-meter reading peaks.
 - b. the output-meter reading should dip as the "S"-meter reading peaks.
 - c. the output-meter reading should remain constant as the "S"-meter reading peaks.
 - d. the "S"-meter reading should remain constant as the output-meter reading peaks.
7. When the strength of the incoming signal increases, the a-v-c voltage:
 - a. becomes more negative.
 - b. becomes less negative.
 - c. becomes more positive.
 - d. stays the same.
8. The beat-frequency oscillator operates at:
 - a. 456 kc.
 - b. 465 kc.
 - c. the frequency of the incoming signal.
 - d. 654 kc.
9. The audio output amplifiers are connected:
 - a. in push-pull parallel.
 - b. push-pull.
 - c. as cascade stages of amplification.
 - d. in push-push.
10. The AUDIO GAIN control controls the:
 - a. a-v-c level.
 - b. sensitivity of the intermediate-frequency amplifiers.
 - c. gain of the 2nd detector.
 - d. output level of the receiver.
11. The external power-supply unit for the receiver furnishes:
 - a. filament, plate, and grid-bias voltages.
 - b. filament, screen, and plate voltages.
 - c. screen, plate, and grid-bias voltages.
 - d. filament, screen, plate, and grid-bias voltages.
12. The correct order of alignment of the receiver circuits are:
 - a. i-f amplifiers, r-f amplifiers, a-v-c circuits, and beat-frequency oscillator.
 - b. i-f amplifiers, a-v-c circuits, beat-frequency oscillator, h-f oscillator and r-f amplifiers.
 - c. i-f amplifiers, a-v-c circuits, r-f amplifiers, and beat-frequency oscillator.
 - d. r-f amplifiers, h-f oscillator, i-f amplifiers, a-v-c circuits, and beat-frequency oscillator.
13. To adjust the crystal-filter circuit:
 - a. an oscilloscope and a frequency-modulated signal generator must be used.
 - b. an oscilloscope and an amplitude-modulated signal generator must be used.
 - c. an oscilloscope and a unmodulated signal generator must be used.
 - d. an output meter and an amplitude-modulated signal generator must be used.
14. For the best possible alignment results:
 - a. the h-f oscillator and i-f amplifiers must be aligned together.
 - b. the i-f amplifiers and r-f circuits must be aligned together.
 - c. the h-f oscillator and r-f circuits must be aligned together.
 - d. the h-f oscillator and a-v-c circuits must be aligned together.
15. When aligning the r-f amplifiers:
 - a. it is necessary to repeat the low-frequency and high-frequency adjustments on each band for maximum output-meter reading.
 - b. the high-frequency adjustments are made before the low-frequency adjustments.
 - c. the low-frequency adjustments have no effect upon the high-frequency adjustments.
 - d. the high-frequency adjustments are not critical.
16. In the trouble-shooting procedure, major test points are used to:
 - a. isolate the faulty circuit.
 - b. locate the defective part.
 - c. align the receiver.
 - d. localize the trouble to a particular section.
17. When the receiver operates incorrectly, the first thing that should be done is to:
 - a. test all the tubes.
 - b. perform a visual check of the condition of the equipment.
 - c. check the operation of the equipment.
 - d. check the voltages at the power supply.
18. Excessive dust on the power transformer and potted chokes will cause:
 - a. overheating and consequent damage to these components.
 - b. low voltage from the power supply.
 - c. hum in the receiver.
 - d. the tubes to burn out.
19. The tubes of the receiver should be checked:
 - a. every day.
 - b. every week.
 - c. every three months.
 - d. every month.
20. The "image" frequency is:
 - a. 465 kc. below the desired signal.
 - b. 930 kc. above the desired signal.
 - c. 930 kc. below the desired signal.
 - d. 465 kc. above the desired signal.

ESSAY QUESTIONS

21. What is the function of the a-v-c circuits?
22. Name at least two advantages of having an external power supply.
23. What two very important characteristics of the receiver are determined by the alignment of the receiver circuits?
24. If the i-f amplifiers are properly aligned, what two factors may cause improper calibration of the MAIN TUNING dial?
25. Why is it necessary to perform the preventive-maintenance checks at the specified intervals?

PART II MULTIPLE CHOICE

26. When the SEND-RECEIVE switch is in the SEND position:
 - a. all power is removed from the receiver.
 - b. B+ is removed from all the tubes.
 - c. B+ is removed from the plate and screen of the 1st detector and the plates of both r-f amplifiers.
 - d. B+ is removed from the plate and screen of the 1st detector and h-f oscillator.
27. The BAND SELECTOR switch changes the tuned circuits in the:
 - a. 1st and 2nd r-f amplifiers, h-f oscillator, and 1st detector.
 - b. 1st and 2nd r-f amplifiers and 1st detector.
 - c. 1st and 2nd r-f amplifiers, h-f oscillator, 1st detector, and all three i-f amplifiers.
 - d. 1st and 2nd r-f amplifiers and h-f oscillator.
28. To check the operation of the 1st detector:
 - a. an i-f signal is applied at the test point **F1**.
 - b. an r-f signal is applied at test point **F1**.
 - c. an r-f signal is applied at test point **F**.
 - d. an r-f signal is applied at test point **E**.
29. To check the operation of the 2nd detector:
 - a. an r-f signal is applied at test point **D1**.
 - b. an audio signal is applied at test point **D1**.
 - c. an i-f signal is applied at test point **F1**.
 - d. an i-f signal is applied at test point **D1**.
30. If capacitor C26, in the noise-limiter stage, were to become shorted:
 - a. the 2nd detector would not function correctly.
 - b. the noise-limiter stage would always be on.
 - c. there would be no noise-limiter action.
 - d. the audio output would be very weak.
31. With the LIMITER switch ON, if capacitor C42, in the noise-limiter circuit, were to become short-circuited:
 - a. there would be little or no output heard in the loud-speaker.
 - b. there would be no noise-limiter action, but the output of the receiver would be normal.
 - c. there would be excessive output in the loud-speaker.
 - d. the output of the receiver would have normal volume, but would be very distorted.
32. If capacitor C18B, in the a-v-c bus, were to become short-circuited:
 - a. the receiver would have increased selectivity.
 - b. the receiver would become inoperative.
 - c. the receiver would have increased sensitivity.
 - d. the receiver would operate normally.
33. When no signal is received the minimum amount of voltage on the a-v-c bus is:
 - a. -20v.
 - b. +10v.
 - c. -3v.
 - d. -15v.
34. If capacitor C41 were to become defective (open circuited):
 - a. the beat-frequency oscillator would stop oscillating.
 - b. the beat-frequency oscillator would become detuned.
 - c. no output would be obtained from the receiver on c-w signals regardless of the position of the SIGNAL switch.
 - d. no output would be obtained from the receiver on c-w signals with the SIGNAL switch in c-w position.
35. The output of the beat frequency oscillator is mixed with:
 - a. the output of the 3rd i-f amplifier.
 - b. the output of the 2nd detector.
 - c. the input of the 3rd i-f amplifier.
 - d. the input of the a-v-c amplifier.
36. To determine whether the beat-frequency oscillator is oscillating:
 - a. measure the d-c voltage at the plate of V10.
 - b. measure the d-c voltage at the grid of V10 by means of a vacuum-tube voltmeter.
 - c. measure the d-c plate voltage at the plate of V7.
 - d. measure the d-c voltage of the grid of V7.
37. If V15, the audio output amplifier, were to become defective (filament open):
 - a. the receiver would not function at all.
 - b. the output of the receiver would be weak.
 - c. the output of the receiver would not be affected.
 - d. the receiver could be used only for c.w. operation.
38. If capacitor C25, in the audio-amplifier section, were to become shorted:
 - a. the output of the receiver would be low and distorted.
 - b. the output of the receiver would be high and distorted.
 - c. the receiver would operate normally.
 - d. the receiver would operate intermittently.
39. The proper power-supply unit for an input voltage of 95 volts is the:
 - a. RA-74-C.
 - b. RA-74-C or R-84-B.
 - c. RA-84-B.
 - d. RA-94-C.

40. If choke L2 were to burn out, incorrect voltages would be obtained at:

- a. test points , , and .
- b. test points , , and .
- c. test points , , and .
- d. test points , , and .

41. If resistor R2C, in the power supply, were to burn out:

- a. no B+ voltage would be supplied to the receiver.
- b. no B+ or screen voltage would be supplied to the receiver.
- c. the audio output amplifiers would have no B+ voltage.
- d. the SENSITIVITY control would have no effect upon the operation of the receiver.

42. If, when making the operational check of the receiver, the dial lights do not light, the first thing to do is:

- a. check the pilot lights.
- b. check the fuse.
- c. check the voltages at the power supply.
- d. check all the tubes.

43. A poor i-f rejection ratio may be caused by:

- a. misaligned i-f amplifiers.
- b. a burned out crystal.
- c. improperly placed i-f or r-f leads.
- d. misaligned a-v-c amplifier.

44. If the power output is low and the receiver is accurately aligned, the most logical thing to check is:

- a. the fuse.
- b. the "C"—bias rectifier.
- c. the a-v-c rectifier.
- d. all the tubes.

45. The receiver sensitivity for modulated signals on all bands is:

- a. 5 microvolts.
- b. 2 millivolts.
- c. 2 microvolts.
- d. 10 microvolts.

ESSAY QUESTIONS

46. What components in the noise limiter determine the time duration of the noise pulses that will be eliminated by the noise-limiter stage?

47. When a.v.c. is used for cw operation, how is the time constant of the a.v.c. system increased to prevent the a-v-c voltage from varying when the carrier is keyed?

48. How does the SIGNAL switch turn the beat-frequency oscillator on?

49. How are the output-amplifier tubes biased?

50. Noisy operation of which stages is most apt to affect the signal (plus noise)-to-noise ratio.

REVIEW OF FINAL EXAMINATION

Display Wall Charts No. 1 and No. 2 and, using the examination, review each question and give the correct answers. This review normally requires about two hours. Fully explain any question which causes

the students difficulty. At regular intervals the students should be allowed to ask questions of their own, and engage in classroom discussions pertaining to those questions.

